It is not wise to apply packing of iodoform gauze over the surface of small intestines, inasmuch as fixation by lymph and the establishment of a blockade by kinking are likely to occur. This principle does not apply to the colon, however, upon which packing may freely be applied.

The after-care of cases of intestinal surgery is important and includes light fluid diet for four days, enemata every day, copious draughts of water or nutritious broths, gentle calomel action (gr. $\frac{1}{4}$ every quarter of an hour for six doses) on the morning of the third day. The author has made it a rule, in these cases, never to give salts after calomel—or indeed at any time soon after the operation—for the reason that no purgative is so likely to be repelled by the stomach; and if a reverse peristaltic action is initiated in vomiting, any natural downward peristalsis which is proceeding in the intestines will also be reversed and the wholesome relief of gas and intestinal contents will be abruptly arrested.

The following very brief review of the operations on intestines and maladies for which they will be required will aid the reader to comprehend the whole.

Enterotomy, or simple incision into the bowel, may be needed, first, to relieve accumulated gas, confined by stricture, kink, volvulus, or hernia; second, to remove an enterolith or foreign body held in the intestine (usually by stricture, due to the long detention in the bowel). In such an event a linear incision should be made in the intestine, just at the upper part of the foreign body. The latter is then worked back to the opening and removed, after which sutures are more safely applied than if the cut were made at the point of stricture. For gas distention or fæcal accumulation an incision can generally be sewed up tightly after evacuation. The parts are then rinsed and dropped back into the abdominal cavity. If relief is difficult, owing to arrest of peristalsis, there is little to be hoped for from evacuating gas, as the paralysis of the intestinal coats due to septic poison practically disables them from resuming their function.

If a gangrenous loop of bowel is resected and the patient's condition warrants it, anastomosis by Murphy button, thorough cleansing of the neighborhood and of the pelvis by pads wet with salt solution, will give the best results.

If the patient is in bad condition, an artificial anus is temporarily established by simple enterotomy.

Enterostomy, or permanent drainage of the small intestine, is a most undesirable procedure. A lateral anastomosis with a neighboring coil, or with the colon, should be preferred if the malignant growth, for example, cannot be removed safely and one must simply circumvent the obstruction. Simple suture may be ample for small ulcers, stab wounds, or perforations, but for larger ulcers one may be obliged to do the elbow suture, described above, or stitch the rent to a neighboring sound bowel surface, or use a button anastomosis.

In typhoid perforating ulcer the author has tried a variety of operative methods, and is disposed to advise putting a small button into the fistula and anastomosing it to a near-by part of the caput coli or ascending colon. This advice is given, first, because the ulcer is generally located within a foot or a foot and a half of the ileo-cæcal valve, and consequently no serious amount of intestine would be put out of commission. In the next place, there would be easy and certain discharge of gas and intestinal contents into the colon. Third, it leaves the operator the greatest liberty to wash out the abdominal cavity thoroughly with salt solution and close it by strapping without sutures, after drawing the omentum well down over the intestines and laying iodoform gauze between the edges of the wound and upon the omentum. A pelvic drainage tube is advisable but not always essential. Avoidance of abdominal wall sutures diminishes the likelihood of secondary infection cultures around the anæmic areas held tightly by the suture, at which points, in the author's experience, sepsis is apt to reoriginate.

Anastomosis.—"End-to-end" or "lateral" will be required when resection has to be done: first, to remove a malignant or non-malignant stricture; second, to circumvent an inoperable stricture; third, after resection for gangrene, for laceration, or for large perforations.

Robert Abbe.

INTESTINES, HISTOLOGY OF.—The layers recognized in a typical section of the intestinal tract (see Fig. 2934) are as follows, named from within outward:

- Mucosa (Mucous Membrane).
  - Epithelium.
  - Tunica Propria.
  - Muscularis Mucosæ.
- Submucosa.
- Muscularis.
  - Circular Layer.
  - Longitudinal Layer.
- Serosa.
  - Subserosa.
  - Endothelium.

The *epithelium* lining the intestinal tract and its glands and covering its villi and valves is derived from the entoderm, or inner germ layer. It is the only portion so derived, the much more conspicuous remaining layers arising from the mesoderm.

The epithelium consists throughout the intestines of a single layer of columnar cells. They have distinct cell walls, and on their free extremities a thickened end-plate, with fine striations parallel with the long axis of the cell. In sections the end-plates appear to be continuous from cell to cell, forming a cuticular border, varying in prominence in different sections. It is lacking in the glands and crypts. There are no cilia.

The rounded nucleus of the epithelial cell is placed nearer the deeper than the superficial end of the cell and divides the protoplasm into supranuclear and infranuclear portions. These differ geatly in function, and at times differ greatly in appearance. Cell division (mitosis) occurs only in the deeper portions of the crypts, and the cells here formed move to the more superficial regions and up on to the villi, so that tips of the villi bear the oldest cells.

Mucus appears in the supranuclear portions of the epithelial cells—probably it may appear in any—in the form of small vacuoles, which increase in size or fuse. Further increase of the mucus causes the cell to bulge laterally at the expense of its neighbors, and gives it its characteristic shape and name—"goblet cell." The protoplasm and nucleus are pushed down and the nucleus becomes flattened or triangular. The free border of the cell bulges into the lumen of the gland or of the intestine, and finally perforates through a well-defined, circular opening. The cell then shrinks into a narrow, deeply stained, rod-like structure, and probably at last resumes its original appearance. The goblet cells are easily recognized by their shape and by their staining, as the mucus generally takes a color different from that of the protoplasm, the color differing with different stains. The number of goblet cells differs in different parts of the intestine and varies with the stage of digestion.

Leucocytes are often observed between the epithelial cells. They are recognized by the smaller size and deeper staining of the nucleus compared with that of the epithelial cell. The nucleus is usually surrounded by a pale halo, representing the protoplasm. According to Stöhr they are in the act of wandering into the lumen of the intestine.

The intestinal glands or crypts of Lieberkühn are found in all parts of the intestine. They are simple tubular glands, seldom branching. They extend nearly down to the muscularis mucosæ. Goblet cells are present except in the extreme fundi. Evidences of cell division are present, as has already been said, in their deeper portions, and where it occurs the nuclei move nearer to the exposed ends of the cells and out of the row formed by the other nuclei. They differ but slightly in different regions of the intestines.

Beneath the epithelium there is a basement membrane, upon which the cells rest. Opinions as to its structure and significance differ.

The *tunica propria* throughout the intestines consists of typical reticular tissue containing lymph cells. Mall describes three kinds of fibres found in the various forms of connective tissue—white, fibrillated fibres, yellow elastic fibres, and reticulum fibres. He shows that the mucous membrane of the intestine contains none of the elastic structures, and but few of the white fibrils. The reticulum is, however, unusually well developed. In the tunica propria are found numerous capillaries, some of whose branches make networks about the glands and in the villi; lymph spaces, and smooth muscle fibres derived from the muscularis mucosæ. There are also numerous leucocytes, particularly lymphocytes. These are in some places collected into masses, forming the Peyer's patches and solitary nodules, presently to be described.

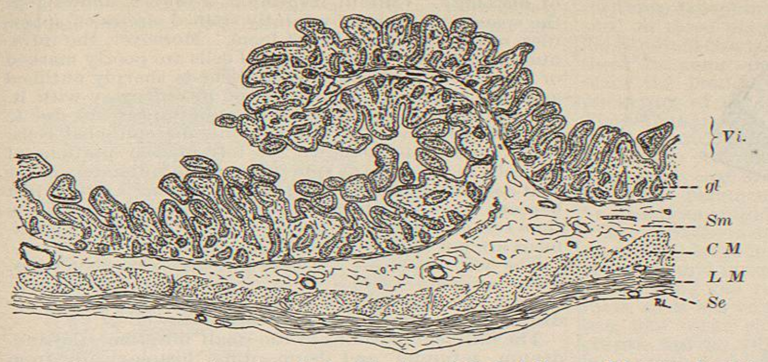

FIG. 2930.—Small Intestine. Longitudinal Section of Wall of Human Jejunum, showing One of the Valvulæ Conniventes. (From author's own drawing.) *Vi*, Villi; *gl*, glands or crypts of Lieberkühn; *Sm*, submucosa; *C M*, circular muscle layer; *L M*, longitudinal muscle layer; *Se*, serosa.

The *muscularis mucosæ* consists of a delicate sheath of non-striated muscle fibres, lying between the tunica propria and the submucosa. The fibres are arranged in two layers like those of the muscularis proper—an inner circular and an outer longitudinal. Fibres branch off from the muscularis mucosæ and run up between the glands and into the villi. The function of this layer is to compress the mucous membrane and thus aid the passage of fluids through it.

The *submucosa* is a wide layer of loose areolar connective tissue. The elastic network is fairly well developed. The layer contains numerous blood-vessels, and through it must also pass nerve fibres and lymphatics. Fat cells are often observed.

The *muscularis* is composed of involuntary or smooth fibres arranged in two compact sheets or layers. The inner layer has its fibres arranged circularly about the lumen of the intestine. The outer layer is composed of fibres running longitudinally. The proportionate thickness of the two layers varies but little. The circular sheath is much the thicker, as the drawings illustrating this article show. The arrangement of the muscular layers is essentially alike throughout the intestine. It is evident that by observing the direction of the fibres we can always tell the direction in which a given section was cut. Thus a section parallel to the long axis of the intestine always cuts the fibres of the outer layer of muscles longitudinally and those of the inner layer across. A section cut across the lumen of the intestinal tube always shows an inner layer of muscle fibres cut longitudinally and an outer layer cut across.

The *serosa* is the outermost layer. In consists of a thin sheet of connective tissue, the subserosa, separating the peritoneal endothelium from the outer muscular layer. The peritoneal endothelium consists of a single layer of greatly flattened cells, so thin that in cross sections under ordinary powers of the microscope they appear like slender lines in which the nuclei are bulging dots. In cross sections it will be seen that where the intestinal tube is attached to the mesentery, the peritoneal later is continued over on to the latter, while the subserous connective tissue is thickened and continuous with the connective tissue of the mesentery and with the adventitia of the vessels entering and leaving the intestine at this point. The peritoneal endothelium is of course lacking over portions of the intestinal tube, where the latter is attached directly to the abdominal wall, without mesentery, as in the ascending and descending colon, the duodenum and the rectum.

THE SMALL INTESTINE.—This part of the alimentary canal is characterized by the presence of villi. These are found nowhere else in the intestinal tract.

Villi are finger-like projections of the mucous membrane into the lumen of the intestine, involving the epithelium and tunica propria (see Figs. 2930, 2933, and 2931). They are about a millimetre high. The inner surface of the intestinal canal is thickly studded with them all the way from the pylorus to the ileo-cæcal valve. They are so numerous that hardened specimens have the appearance of velvet. Their number has been

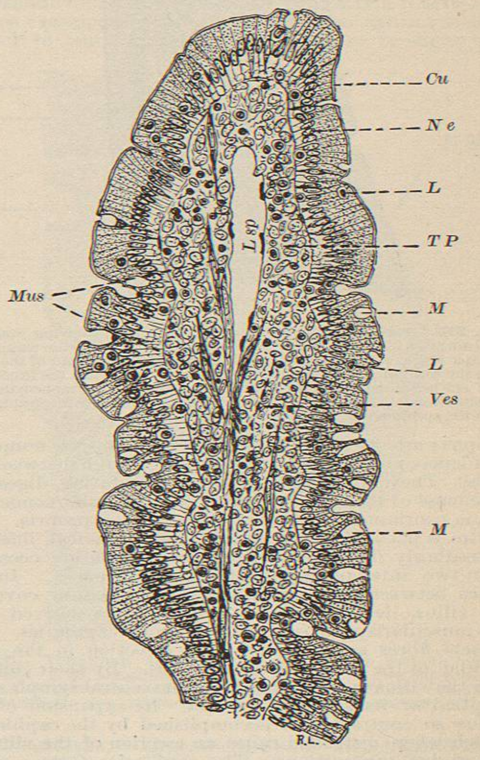

FIG. 2931.—Villus from Small Intestine of Java Monkey, showing Dilated Central Lymph Space (*L sp*). (From author's own drawing.) *Cu*, Cuticular border of epithelial cells; *N e*, nucleus of epithelial cell; *L*, lymphocytes; *T P*, tunica propria; *M*, mucous cells; *Ves*, blood-vessel; *Mus*, smooth muscle fibres; *L sp*, central lymph space.

estimated at four millions. Obviously, by their means the absorbing surface is enormously increased.

The villus is covered with epithelium continuous with the general epithelium of the intestine. In the cells fat

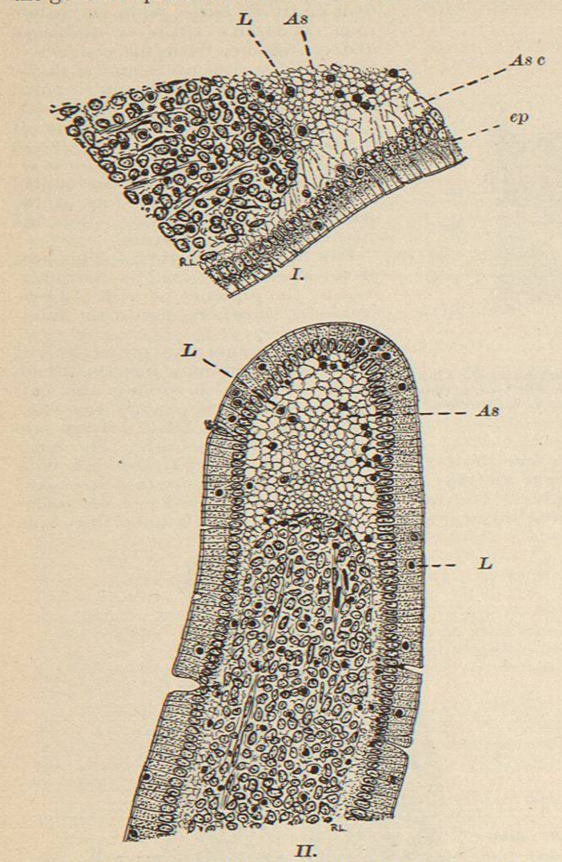

FIG. 2932.—Portions of Villi from Cat's Intestine, showing Stages of Absorption. (From author's own drawings.) I., Earlier stage. II., Later stage. *As*, Absorbed material occupying the end of the villus in the form of spherules; *As c*, the same, occupying the inner ends of epithelial cells not yet entirely destroyed; *L*, lymphocytes; *ep*, epithelium. (The spherules are here exaggerated in prominence. In the specimen they were but faintly colored.)

droplets are often recognized. Goblet cells are numerous and leucocytes are seen wandering through between the cells. They are especially numerous during digestion. The mass of the villus is made up of reticular connective tissue continuous with that of the tunica propria. The centre is occupied by a lymph space or lacteal, lined by exceedingly delicate endothelium. There are occasionally two intercommunicating lymph spaces. In the space between the lacteal and the epithelium, covering the villus, lie a few smooth muscle fibres derived from the muscularis mucosæ, and numerous capillaries. The muscle fibres are disposed in a direction in the main parallel to the long axis of the villus. By their contraction the villus is compressed and the central lymph space emptied of its absorbed lymph. Re-expansion of the villus so contracted is accomplished by the capillaries, which when distended cause an erection of the villus to its original proportions. The capillaries form a dense network immediately beneath the epithelium. The blood entering the villus and leaving it, occupies larger vessels more deeply situated.

Favorable sections of the small intestine often show the reticular tissue forming the axis of the villus to be separated from the epithelium, especially near its tip, by a considerable space. This has ordinarily been considered an artefact, and is so labelled in one of our best text-books of histology. Careful inspection, however, shows that the space is occupied by faintly stained circles or spherules resembling a section of foam. Moreover, the infranuclear portions of the epithelial cells are poorly marked or missing, while the reticular tissue is sharply outlined as if the basement membrane had pulled away with it. According to Mingazzini, these appearances are due to the absorption of food material by the epithelial cells. Such material is stored in the infranuclear portions of the cells in the form of spherules, which ultimately cause that end of the cell to break down, leaving a space just beneath the epithelium filled with the spherules. For a time cell outlines are preserved, and in favorable specimens are not difficult to see (Fig. 2932, I).

The villi, then, are decidedly complicated structures. Their presence enables us to recognize at once a specimen of the small intestine when seen in section, and to distinguish it from other parts of the bowel.

The different portions of the small intestine—the duodenum, jejunum, and ileum—differ histologically from one another only in detail.

The *duodenum* is characterized by the presence, along with the simple crypts, of *Brunner's glands*. These, in marked distinction from the simple intestinal crypts, are situated chiefly below the muscularis mucosæ in the submucosa, from which the ducts lead up through the tunica propria to empty into the crypts or at the bases of the villi. The glands are of the branched, alveolar type. Their cells closely resemble those of the pyloric glands of the stomach. Moreover, as they show certain changes during digestion, it is probable that they secrete a digestive fluid. Their appearance is shown in Fig. 2933. They are most numerous in the upper portion of

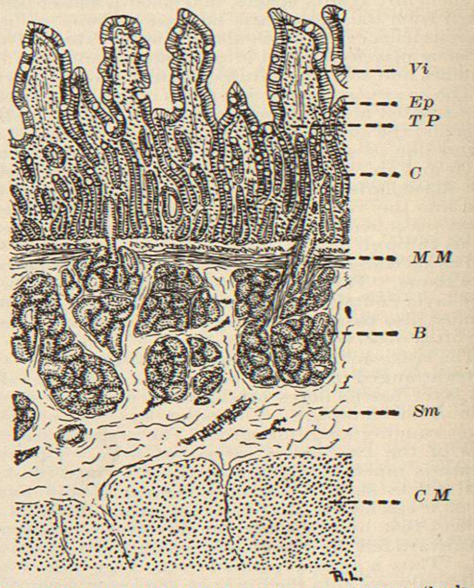

FIG. 2933.—Portion of Wall of Cat's Duodenum. (From author's own drawing.) *Vi*, Villus; *ep*, epithelium; *T P*, tunica propria; *C*, crypt; *M M*, muscularis mucosæ; *B*, Brunner's glands; *Sm*, submucosa; *C M*, circular muscle layer.

the duodenum. This part of the intestine is further characterized by the shortness of its villi and by the presence, in its lower part, of valvulæ conniventes, more characteristic of the jejunum.

At the upper end of the duodenum a fəw gastric pits,

like those of the pylorus, are found, while in the same region the crypts are poorly developed. In other words, the change from pylorus to duodenum is not, so far as the mucous membrane is concerned, abrupt.

The *jejunum* and *ileum* present no striking differences from one another. We may say, however, that in the

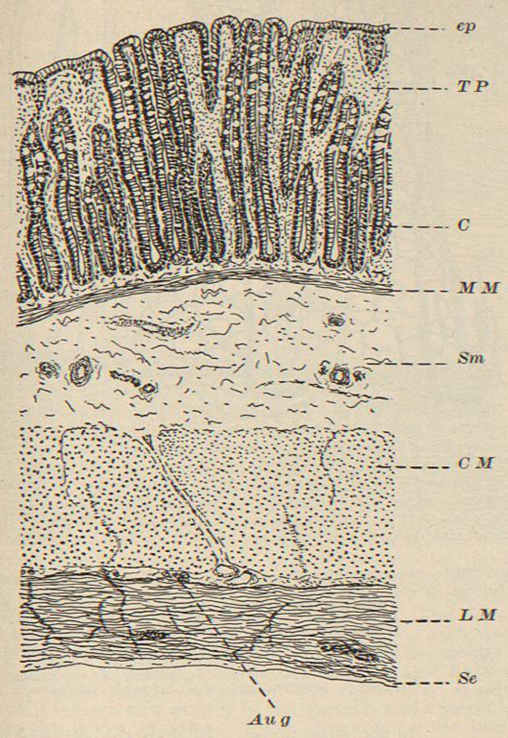

FIG. 2934.—Large Intestine of Cat. (From author's own drawing.) *Ep*, Epithelium; *T P*, tunica propria; *C*, crypts of Lieberkühn; *M M*, muscularis mucosæ; *Sm*, submucosa; *C M*, circular muscle layer; *L M*, longitudinal muscle layer; *Se*, serosa; *Au g*, ganglion of Auerbach's plexus.

case of each, peculiar structures may dominate the histological picture, viz., the valvulæ conniventes in the jejunum, and the Peyer's patches in the ileum. *Valvulæ conniventes* or plicæ circulares are folds involving the mucous membrane and the submucosa, and partly surrounding the lumen of the intestine (see Fig. 2930). They make, as it were crescentic shelves. They are especially numerous in the lower duodenum and jejunum. The patches of Peyer will be discussed below. The villi of the jejunum are longer than in the duodenum, while in the ileum they are longest of all, and tend to be club-shaped. Toward the lower end of the small intestine they again decrease in length.

THE LARGE INTESTINE.—The large intestine is characterized histologically by the absence of villi. The crypts are about twice as deep as in the small intestine, and are straighter and more numerous and crowded. Their epithelium is thickly studded with goblet cells, especially near their mouths, much more so than in the small intestine. According to Stöhr, this is due to the fact that the movements of the epithelium from the depths of the glands, where active proliferation takes place in the cells, are slower than in the small intestine where the new cells have to travel clear to the tops of the villi. As the distance to be travelled is less than in the small intestine, the goblet cells have more time to develop and appear thicker and more numerous. The tunica propria, owing to the greater number of crypts, is less extensive than in the small intestine. It contains muscle fibres. The muscularis mucosæ and the submucosa are similar to the same structures in the small intestine. The longitudinal muscle fibres, except in the rectum and appendix, are strengthened in three places in the circumference into flattened longitudinal bands—posterior, anterior, and inferior. As these are somewhat contracted the large intestine presents the familiar sacculated appearance, due to the puckering of the intervening thinner parts of the wall. The serous layer is exactly like that of the small intestine in structure. In the ascending and descending colon there is no peritoneal epithelium on the posterior aspect. The serous coat of the colon is, here and there, prolonged into little pedunculated tabs, filled with fat and called "appendices epiplöicæ."

The *vermiform appendix* has a structure essentially like that of the large intestine. It has the same arrangement of serous and muscular layers. The mucous membrane surrounding the relatively small lumen is thrown into folds, as is shown in Fig. 2935. The mucous membrane has, like other parts of the large intestine, abundant crypts, but no villi. The most marked feature is the large number of lymphoid nodules. These are so numerous that the appendix might appropriately be described as a Peyer's patch. The bearing of this on typhoid fever and appendicitis is obvious and is not always appreciated by clinicians.

In many individuals the lumen of the appendix is found to be obliterated. The mucous membrane has almost or entirely disappeared, and is replaced by fat, the centre of the organ being occupied by a cord of connective tissue. Zuckerkandl found this condition in nearly a fourth of the cases examined. Though it would be natural to attribute it to senile degenerative changes or to slight or

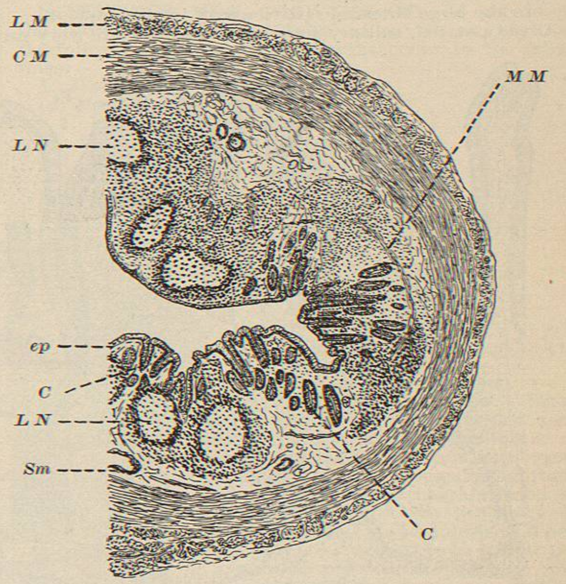

FIG. 2935.—Vermiform Appendix, Human. (From author's own drawing.) *L M*, Longitudinal muscle layer; *C M*, circular muscle layer; *L N*, germ centre of lymph nodule; *ep*, epithelium; *C*, crypts of Lieberkühn; *Sm*, submucosa; *M M*, muscularis mucosæ.

forgotten attacks of appendicitis, both Zuckerkandl and Ribbert consider it to be a normal process taking place in an organ that has become functionless.

At the ileo-cæcal valve, where the cæcum begins and the ileum ends, there is a somewhat complicated arrangement of the mucous membrane. Even above the ileum