Neill (John)

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ART. I.—*On the Structure of the Mucous Membrane of the Human Stomach.* By JOHN NEILL, M. D., Demonstrator of Anatomy in the University of Pennsylvania. (Read before the College of Physicians of Philadelphia.) [With a coloured plate.]

IT is with some hesitation that we present before this College a paper containing even an intimation that anything new connected with so well studied a structure as that of the human stomach is yet to be observed or described.

Neither are we yet prepared to make the assertion that more recent and protracted examinations have brought to light any specific elementary formation not noticed before, in some disconnected way, and allied with much that is irrelevant and imaginary.

By the aid of microscopic and minute injections, we have been led to the conviction that, as a whole, the internal surface of the stomach has not been fully represented in any description or diagram. Notwithstanding all that older anatomists have written, shall we not be sustained in the statement that their views concerning this elaborate and complicated structure are confused and contradictory? And although modern authorities are more uniform, may not their uniformity be the result of the adoption of a common error?

We should state that it is not the epithelial, but the true surface of the mucous membrane of the stomach to which we wish to call attention, and the facts we shall present can be observed by any one in the preparations upon the table.

The surface of the mucous membrane presents different appearances in different portions of the stomach; this fact not having been sufficiently appreciated by observers, we consider as one of the sources of error in the ordinary descriptions of this organ. By far the larger portion exhibits various modifications of the honeycomb structure, the cells are large and polygonal in some parts,

in others, they are smaller, deeper, and rounder; the ridges between these cells are formed of one or more convoluted capillaries, and this arrangement of capillaries is particularly evident in the rugæ. (See Fig. I.) The walls of these cells or pockets are formed of a network of capillaries, which subdivides each cell into smaller ones; these cells are what are ordinarily called the orifices of gastric glands, and the subdivision in the bottom of each cell corresponds with the described orifices of tubuli. In the antrum pylori, the structure is modified, the ridges between the cells become larger, more elevated, (See Fig. II.), and as we approach the pyloric orifice, *conical villi* make their appearance; these villi are more numerous and larger towards the pyloric valve, so that fewer of the angular or polygonal cells are visible in their interstices; they are not so large as the villi of the small intestine, but in other respects their external appearances are precisely similar. (See Fig. III.) When well injected, they seem to be composed of capillaries, closely united by a basement membrane, and forming a pyramidal projection.

There may be said to be three different appearances presented by the microscopic examination of the injected capillaries of the mucous membrane of the stomach when deprived of its epithelium. First. The convexity of a large ruga will have a comparatively smooth and even appearance formed by convoluted and intertwining capillaries. Second. Any other portion excepting the antrum will exhibit cells or alveoli of different sizes and shapes, separated by ridges of various thicknesses, and these ridges are composed of capillaries arranged in the same manner as in the rugæ. Third. In the antrum pylori there are *conical villi*, and cells exist in the interstices and at their bases.

That the main point which we wish to prove may be understood in a few words, we would simply state that we consider the capillaries arranged in the form of "ridges, cells, and *villi*." The question may now arise whether this description in any manner deviates from those ordinarily given in the standard works of the day? We consider that it does, particularly with reference to the villi, the existence of which, in the stomach, we wish fully to establish by description and demonstration. It might be asked whether the term *villous* has not constantly been used with reference to the mucous membrane of the stomach? Unquestionably it has, though in a vague and loose way, as indicating a smooth, velvety surface; but not as implying a vascular, papillary projection to which the term *villus* is applied in the intestine.

To corroborate the statement, that it is generally believed that villi do not exist in the stomach, we have only to refer to recent anatomical and physiological writers on the subject. Kirkes and Paget* teach us not only that there are

* "Presents a peculiar honeycomb appearance produced by shallow polygonal depressions or cells. They are separated by highly elevated ridges, which sometimes, especially in *morbid states* of the stomach, bear minute narrow vascular processes, *that look like villi*, and have given rise to the *erroneous* supposition that the stomach has absorbing villi like those of the intestine. In the bottom of the cells are minute openings, &c., which are the orifices of perpendicular glands."—p. 165.

no villi in a healthy stomach, but that the cellular and honeycomb appearance characterizes the whole of its mucous membrane, and that the appearance is *uniform*. Neither Wilson nor Todd and Bowman speak of villi in the stomach. Carpenter* refers to "pointed processes that have been *mistaken by some anatomists* for villi."

Hassall has neither drawing nor description of gastric villi in his Microscopic Anatomy.

Horner† says "that none exist in the stomach or colon."

Quain and Sharpey‡ state "that these pointed processes may be compared to rudimentary villi, the perfect form of which only exists in the small intestine."

Harrison,§ of the Dublin Dissector, denies the existence of true villi.

Hodgkin‖ seems to be ignorant of this structure in the stomach.

Now these authorities are sufficiently numerous and authoritative to convince us that although the term *villous* has been used with reference to the stomach, yet the authors just quoted do not believe that *villi* exist in the stomach.

On the contrary, a number of other writers say that villi *do exist* in the

* "These pits are more or less circular in form, and are separated from one another by partition—like elevations of the membrane which vary in depth; and sometimes even by pointed processes *that have been mistaken by some anatomists for villi*."—p. 659.

† "The mucous coat of the alimentary canal in a healthy state, and successfully injected, appears to consist almost entirely of a cribriform intertexture of veins." "In the whole length of the intestine there is, however, every variety of shape of villi, from oblong, curved and serpentine ridges, to the laterally flattened cone standing on its base, &c. Conformably to this definition of villi, none exist either in the stomach or colon."—Vol. ii. p. 54.

‡ "It is seen to be marked throughout, but more plainly towards the pyloric extremity, with little depressions or cells, named alveoli, which have a polygonal form." "The margins of these alveoli are elevated into pointed processes, which may be compared to *rudimentary villi;* the perfect form of these appendages only existing in the small intestine, and making their appearance in the duodenum."—Part III. p. 1025.

§ "Numerous follicular papillæ, but not true villi, project, and leave between them small depressions or pits studded with minute holes; these pits are more or less circular, and are bounded and separated by the follicular elevations; they are more distinct towards the pyloric portion of the stomach; four or five foramina are seen in each: these are the orifices of the small glands and ducts that elaborate the gastric fluid, the mucous being probably furnished by the follicles."—Vol. i. p. 244.

‖ "In fact, the surface of the mucous membrane of the stomach is generally described as villous: and even Billard appears to agree with this description of it. I have at least a doubt respecting the accuracy of this statement. To me the surface of the stomach, when viewed under the circumstances which I have mentioned, appears to the naked eye by no means perfectly smooth, but of an indeterminate character, very difficult to describe." "Whilst in the *serous* membranes, the assistance of a powerful microscope enables us to distinguish delicate fibres intimately interlaced, when the *mucous* membrane of the stomach is thus examined, *I can only observe an amorphous semi-transparent* mass in which no structural texture can be distinguished."—Lect. xix. p. 270.

stomach, and give descriptions of them, though none have made drawings of them but Berres,* whose magnificent work has fallen into my hands since the artist has given the accompanying representations. With the exception of Berres, we believe no one has had the knowledge of this structure, although Bèclard† says "the villosities are nowhere more numerous than in the pyloric half of the stomach and small intestine;" and again, in a succeeding paragraph, says, "they are shorter and *less numerous in the stomach* and large intestine," and in another denies the vascularity of them. If Bèclard's injections could not exhibit the vascularity of these villi, it is hardly probable that he could have any accurate idea of the structure, for it is only by successfully executed injections that the true form of the villi can be determined. An opinion founded on no better data can hardly be more than an hypothesis, or an inference from the nature of the surface in other portions of the alimentary canal.

Such also may be considered the value of Bichat's‡ statement upon this point. He *reasons* that they exist there, because they do in other parts; his

* Anat. Microsc. Corp. Humani. Auct. Dr. Josepho Berres, Prof., &c. Vienna, 1837.

† "The villosities whose existence is very general, but which are nowhere more numerous, larger, or more apparent than in the pyloric half of the stomach, and in the small intestines, and especially in the commencement of that intestine, are eminences still finer than the papillæ."

"These villosities may with propriety be called the *radicals* of animals, are small foliaceous prolongations of the internal membrane," &c. "Were first described by Fallopius and Azelli, and have been figured by Helvetius, Lieberkuhn, Hedwig, Rudolphi, Meckel, Buerger, and others, especially in the small intestine, being shorter and less numerous in the stomach and large intestines."

"Those of the pyloric half of the stomach and duodenum are broader than long, and constitute a small lamina." "There is not perceived the vascular texture which has been described as belonging to them."—*Elem. Gen. Anat.*, Béclard, translated by Knox, 1830.

‡ The papilla of this system cannot be called in question at its origin, where it dips into the cavities, in the commencement even of these cavities, as upon the tongue, the palate, the internal part of the alæ of the nose, upon the glans penis, in the fossa navicularis, within the lips, &c. Inspection is sufficient to demonstrate them there. But it is asked if the papilla exist also in the deep-seated parts of this system. Analogy indicates it, since the sensibility is as great there as at their origin, though with varieties that we shall point out; but inspection proves it in a manner not less certain. I think the villi with which we everywhere see them covered are nothing but these papillæ. This manner of regarding them by explaining their existence generally observed upon all the mucous surfaces, appears to me to be much more conformable to the plan of nature, than to suppose them in each place with different and often opposite functions. Besides, it is difficult to decide the question by ocular observation. The delicacy of these elongations conceals their structure, even from our microscopical instruments—agents from which anatomy and physiology do not appear to me to have derived much assistance, because when we see obscurely, each sees in his own way and according to his own wishes. It is then the observation of vital properties that should especially guide us; now it is evident to judge by them, that the villi have the nature I have attributed to them."—*Bichat, Hayward's Translation*, 1822.

generalizations lead him to assert the existence of structures we fear he had never seen. He says "analogy indicates it," but "it is difficult to decide the question by ocular demonstration."

Billard, in his work on "Mucous Membranes," speaks of the stomach as possessing villi, and says, "they exist *generally* over its surface" (with which we cannot agree), although he describes them as "more numerous towards the pylorus," and that "in the healthy stomach the naked eye perceives them but indistinctly."

Huschke* seems to have appreciated the labors of Berres on this point, and admits that the pyloric portion contains villi: and Krause also speaks of "villous folds."

We thus see that even modern writers do not agree; and if this diversity of opinion exists at the present time amid the advantages which we possess, we should not be surprised at the conflicting testimony of those of older times.

Some expressions in Haller† might lead us to suppose that he had very clear evidence of the existence of villi, which he describes as "projecting into the cavity of the stomach;" he speaks also of "the inhaling veins opening in the pendulous villi."

Ruysch‡ gives a drawing from one of his minute injections, which exhibits

* Mais les cloisons interposées entre les glandes tubuleuses méritent de fixer l'attention. Sur les dentelures qui servent de limite si tranchée entre l'épithélium de l'œsophage et le commencement de l'estomac, il-y-a, suivant Berres, des papilles longues de 1-17 à 1-18 de ligne, sur 1-64 d'épaisseur, dans chacune desquelles pénètre une anse vasculaire de 1-139 de ligne. Ces papilles servent peut être à procurer une plus grande sensibilité aux points où elles existent. Dans le reste de l'estomac, les parois intermédiaires entre les orifices des glandes ne s'élèvent pas d'une manière notable, et l'estomac n'a point, par conséquent, des villosités proprement dites, quoique sa membrane muqueuse fasse le passage, par son aspect tomenteux, à celles qu'on nomme villeuses. Mais les choses changent lorsqu'on approche du pylore. Ici, non seulement le membrane muqueuse devient plus épaisse, mais encore sa surface acquiert rapidement une tout autre apparence, qui mène à la formation des villosités de duodénum. Voici comment j'ai trouvé la métamorphose. Les orifices des glandes tubuleuses s'élargissent rapidement, et leurs intervalles commencent à se soulerer, deviennent par là mobiles et flottants, et acquièrent des bords en crête de coq, c'est-à-dire pourvus de pétites points à trois dents. Pendant que ces bords s'élèvent ainsi en manière de plis ou de lames que Krause nomme *plicæ villosæ*, et auxquels il assigne 1-28 à 1-19 de ligne de hauteur, sur 1-56 à 1-28 de large, le fond des glandules tubuleuses se rapproche aussi davantage de la surface, et leur cavité tout entière est alors devenue l'intervalle entre les villosités lamelleuses. D'abord leurs parois intermédiaires sont encore tubuleuses; mais quand l'ouverture des glandes s'agrandit, elles ne tardent pas à se recourber irrégulièrement sous des formes diverses, en zig-zag, en rond, en spirale, continuent d'abord de tenir les unes aux autres par des saillies plus ou moins prononcées, et finissent par perdre entièrement ces moyens d'union; de sorte qu'alors les glandules tubuleuses se continuent les unes avec les autres à la surface, et ressemblent plus à un labyrinthe qu'à un rayon de miel ou à un réseau.—*Encyclop. Anat. Traité de Splanchnologie*, par E. Huschke. Paris, 1845.

† Haller's Physiology, vol. ii. p. 161. Lond. 1754.

‡ "Quando enim ventriculi arterias cera replevi rubrâ: posteaque in liquore idoneo ita

the surface of the stomach as consisting of regularly-formed pockets or cells. He speaks also of villi, but nevertheless confesses that his view of this arrangement was only particularly satisfactory in sheep. If he had satisfactorily injected the villi of the stomach, is it not probable that he would have given us a drawing of this structure in his work?

Fordyce says "that as far as I can judge, it seems to be nothing but cellular membrane. When the surface was moderately moist, there seemed to be a number of thin fine membranes crossing each other, so as to form a number of angular cells."

Hewson states that the whole surface of the intestinal tube is covered with villosities, but admits that in the large intestine these bodies are so short, that the surface appears smooth to the naked eye, while no true villi are detected by the microscope; only the partitions between the cells resemble villi in their structure. In the stomach a nearly identical appearance is found. "At the upper part of this organ, the villous coat appears in a microscope like a honeycomb, or like the second stomach of ruminating animals in miniature; that is, full of small cells, which have thin membranous partitions. Towards the pylorus these partitions are lengthened, so as to approach to the shape of the villi in the jejunum."*

That these opinions should have but little weight with writers and teachers at the present day, and that they should be quoted merely as elucidating the history or the literature of the subject, ought not to surprise us, when we learn that their descriptions were generally based upon observations made with the naked eye, or with instruments in which the observers had but little confidence; for both Fordyce and Bichat, although they used microscopes, expressed themselves as deriving no advantage from them. Neither are we disappointed at the want of accuracy in their descriptions, when we reflect that their comparisons were derived in a great measure from the inspection of inferior animals, and that the meaning attached to such terms as cells, alveoli, crypts, pockets, lacuna, glands, villi, papillæ, &c., is conventional, and varies

prius præparatas partes hasce macero, experior tum superficiem interiorem ventriculi et intestini jejuni tunicâ quasa quadam papillosa vestitam esse. Fateri tamen debeo, haud ita evidenter quidem in stomacho humano has papillas apparere, ut quidem in ovillo: quemadmodum hâc in figurâ expressi. Inde itaque et tanto facilius inducimur credere, et in homine ita obtinere, quum obscurius quidem similitudo accedens in homine observetur."—*Ruysch, Dec. Tert.*, p. 34 and 35, 1737.

"Voco autem hanc intestinorum tunicam villo-papillosam, quia animadverti villosam istam superficiem penitus simul esse papillosam, quemadmodum se habent interiora nostrarum Genarum in suo integumento, ut et labia oris, œsophagus, ventriculus, omniaque intestina, quum sit in his omnibus ejusdem apparatus continuata productio. Verum quidem est, in unoquoque non æque clarum id apparere; quum in Labiis genis internis, et in intestinis maiorum hominum tunica hæc papillas hasce nimis manifestas non possideat, attamen in aliis satis conspicua datur."—*Ruysch, Dec. Secunda*, p. 25 and 26.

* Dr. Sprott Boyd's article on the Structure of the Mucous Membrane of the Stomach. *Edin. Med. and Surg. Journal*, 1836.

with the different periods at which the authors above referred to have made public the results of their observations.

We ought next to inquire what is taught by the principal physiological writers of the day upon this subject, and examine the evidence upon which they base their theories, and see how far the structure they demonstrate corresponds with what we may conceive to exist.

The investigations most frequently referred to are those of Sir E. Home and Dr. Sprott Boyd, although the diagrams of Ruysch, Horner, Todd and Bowman, and Berres are far more in accordance with nature. We refer now merely to the mucous membrane, and not to its epithelial investment, which has received so much attention from Wassman, Henle, Wagner, Hassall, and others.

Sir E. Home says: "The structure upon the upper arch of the stomach which when magnified by a common lens had the appearance of glands, is shown by Mr. Bauer to be made up of cells in the form of a honeycomb; this honeycomb structure consists of cells of the greatest depth in this particular situation, but over the whole surface of the cardiac portion of the stomach the appearance is so faint as to require a great magnifying power to render it visible. In the pyloric portion the cells in general have the same appearance, but there are small clusters, the sides of which rise above the surface, giving the appearance of foliated membranes."

And Dr. Sprott Boyd agrees with him, for he says "the appearance of those cells, throughout the cardiac portion of the stomach, corresponds to the representation given of them by Sir E. Home. When the mucous membrane is extended, they appear tolerably regular both in form and size, varying from the one-two hundredth to one-three hundred and fiftieth of an inch in diameter, being smaller in the young man than in the adult subject. Towards the pylorus, the mucous membrane, which is thin throughout the great cul-de-sac of the stomach, becomes considerably thicker, the dimensions of the cells are increased, and an appearance somewhat resembling that described by Sir E. Home is perceptible. He mentions the patches distinguished by the foliated membranes as existing particularly towards the pylorus. They may be found, however, in the cardiac portion of the stomach likewise; perhaps not actually at the great extremity; but certainly opposite the termination of the œsophagus. In the engraving given by Home of these patches, the wall of each cell is represented as rising above the general surface of the stomach, and being cleft into a number, ten or a dozen, of rounded segments, which form a complete fringe about the mouth of the cell. These projections of the mucous membrane are, so far as I have been able to observe, much less numerous. There is no regular fringe, but here and there a prolongation of membrane, resembling an ordinary villus of the intestine, rises from a partition between two cells. These bodies from their small size are not easily distinguished; they give to the surface a more flocculent and velvety appearance than is presented by other parts of the stomach. The cells near the pylorus are in some cases about one one-hun-

dredth of an inch in diameter, and on examining them on a dark ground, and with the aid of a reflector and a magnifier of a quarter of an inch focus, their interior is pretty distinctly seen presenting an appearance similar to what I have presently to describe as existing in the stomach of the pig, where it is more clearly visible and more easily examined. The floor of each cell appears perforated by numerous circular openings, as if a number of tubes opened on it; and on making a vertical section of the mucous membrane, it is seen to be composed of striæ or fibres running perpendicularly from the free surface of the membrane to the cellular coat beneath."

The diagram of Dr. Boyd is the one which is usually copied into the text books of the day. Had it been made from an injected preparation, we think the nature of "cells and the circular openings perforating their floor" would have been more distinctly demonstrated. The circular openings which he considers to be the orifices of *tubule*, which he describes partly from observation, and partly from analogy in the pig's stomach, we consider to be simply the subdivisions of the cells into smaller and deeper ones by the arrangement of the blood-vessels. We have no disposition to make any innovations upon the terms "tubuli," "gastric tubes," "pyloric tubes," &c., but merely wish to show that their parietes are formed of vessels, and that they are elongated cells or alveoli.

It will be a question of great interest to determine the uses of the *Gastric Villi*. Their form and structure, and their resemblance to the intestinal villi would naturally lead us to associate them with the function of absorption, although some, perhaps, who still consider the intestinal villi to be tactile, would wish to ascribe the same character to those of the stomach. We would not imply by the application of this term *villi* that their uses are precisely similar to the villi of the intestine, that is, that they participate in the chyliferous absorption, or that their lymphatics should be called lacteals; on the contrary, we would believe that the fluid which they absorb is very different from that which has to be subjected to the influence of the bile and pancreatic juice previously to its removal from the intestine; for we have neither mesentery attached to the stomach, nor mesenteric glands for lacteals to pass through, did we suppose them originating in the villi of the pylorus. But is there no other absorption from the stomach than that of watery fluids by endosmotic action directly through the parietes of the blood-vessels? May not these villi be the special apparatus for the absorption of the solution of the albuminose compounds? Is there no nutrition except through the villi of the intestine?

EXPLANATION OF THE PLATE.

Fig. 1 exhibits the gastric cells and capillary ridges.

Fig. 2 exhibits the cells becoming deeper and the ridges becoming more elevated and pointed.

Fig. 3 exhibits the *Gastric villi*, together with gastric cells.

Fig. I.

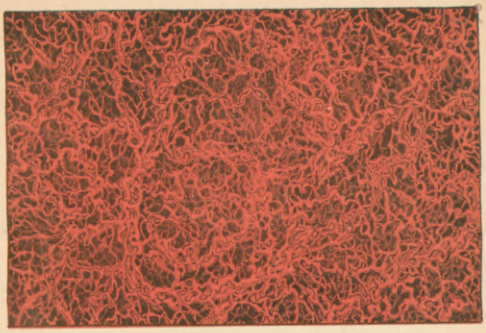

Fig. II.

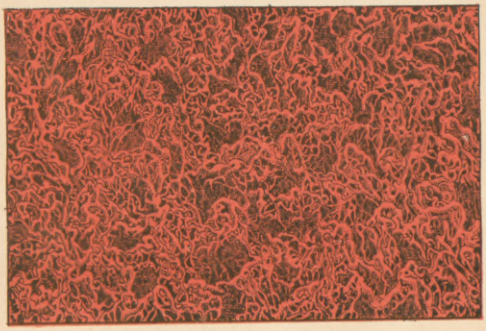

Fig. III.

Lith. of P.S. Duval. Philad.