ON THE RELATION OF THE CENTRAL NERVOUS SYSTEM TO THE ALIMENTARY CANAL.—A STUDY IN EVOLUTION.

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FOR many months I have been closely engaged in studying the pathological anatomy of spina bifida. During the time my attention was directed to this matter, Prof. von Recklinghausen published an interesting and elaborate memoir on Spina Bifida in Virchow's 'Archiv,' Bd. 106, 1886. Not the least important part in that painstaking piece of work, is the section which deals with specimens illustrating the frequent association of certain forms of spina bifida (especially the form known as syringo-myelocoele) with defects in the alimentary canal, such as umbilical hernia, atresia ani, and so forth.

Still more recently I have been engaged in studying the curious condition of the spine known as *spina bifida occulta*, and whilst still fresh from that study, a very remarkable foetus came under my notice, which suggested still further inquiry. The foetus in question will be fully described in the 'Transactions of the Pathological Society,' 1888; it may be briefly stated here that it was the subject of spina bifida occulta in the lower lumbar region. Associated with this defect was, among other things, an imperforated pharynx, a communication between the oesophagus and trachea, atrophy of the vermiform appendix and imperforate rectum.

The conclusions to which I have arrived from an investigation of this material, as well as a careful consideration of the embryological history of the cord and alimentary canal, are, I venture to think, of some degree of novelty and interest, and will be embodied in this paper.

Invertebrates are distinguished from vertebrates, not only in the absence of anything resembling a vertebrate column, but in the non-possession of any structure resembling a spinal cord. To my mind it is clear that the cord must be regarded as primary to the column, that is to say, the cord was first evolved, but the vertebræ are of secondary and much later development.

Of recent years embryologists have brought to light some very remarkable facts relating to the connection of the alimentary canal and the spinal cord, and these facts have become so well established that at the outset of my argument I shall be able to put before you a diagram illustrative of the fundamental arrangement of the alimentary tract, from which the vertebrates of the present day inherit theirs.

The spinal cord, as is well known, is formed by the coalescence of the medullary folds on the *dorsal* aspect of the notochord. The body walls are formed by the coalescence of the somatopleure of each side on the *ventral* aspect of the notochord. Early in embryonic life a layer, the splanchnopleure, is detached from the inner aspect of the somatopleure to form the walls of the gut, by a median ventral coalescence. The outer layers of the ventral laminae form the body wall and are continuous with the outer layers of the medullary folds, which in like manner give rise to the cutaneous investment on the dorsal aspect of the embryo.

Each lamina which helps to form the cord and gut respectively is lined by columnar epithelium. Although in higher types the cells lining the canal of the cord are ciliated, whereas those in the gut are simple, nevertheless it is not difficult to find instances among vertebrates of ciliated cells in the digestive tract. It is a fact of some significance that, so far as embryological knowledge extends, no organ save the gut and the cord is formed by the union of lateral plates.

The valuable researches of Kowalevsky on Ascidians, demonstrating the connection between the central canal of the cord and the gut, around the caudal end of the notochord by means of the neurenteric canal, has since been extended to vertebrata in general, including man, by such competent observers as Kölliker, His, Balfour, Goette, Heape, and others.

A survey of the evidence enables us to represent the primitive alimentary canal as a U-shaped tube lined with a continuous columnar epithelium. Each limb ends at its cephalic extremity in a cul-de-sac. The ventral segment of the tube is widely open to the yolk sac. Occupying the flexure of the tube is the notochord and subnotochordal rod. Fig. 1.

FIG. 1.—THE EMBRYONIC CONDITION OF THE ALIMENTARY CANAL AND CENTRAL NERVOUS SYSTEM OF A MAMMAL.

N. Spinal cord. N.C. Neurenteric canal. y. Intestine. m. Vitelline duct. Y. The yolk sac. CH. Notochord. X. Subnotochordal rod.

FIG. 2.—A DIAGRAM TO REPRESENT THE SUBSEQUENT MODIFICATION OF THE GUT.

s. Stomodæum. x. The pouch of Rathké. L. The diverticulum for the lungs. m. The vitelline duct (Meckel's diverticulum). G. Cloaca. A. Allantois. P. Proctodæum. * Luschka's gland, the persistent remnant of the post-anal gut.

The subsequent events in the ontogeny of these structures is interesting. The limb connected with the yolk sac may, for convenience, be divided into two sections—the fore and hind gut. The anterior end of the fore gut becomes connected with the exterior by an epiblastic involution—the stomodæum, which not only opens up the cephalic end of the gut, but has

close relationship with the cephalic end of the dorsal or neural tube by a diverticulum, the pouch of Rathké, which comes into union with the infundibular diverticulum from the primary encephalic vesicle. The coalescence of the stomodæum and fore gut results in the establishment of a communication between the pharynx and œsophagus.

An involution next appears in the caudal region—the procotodæum—which coalesces with the tube and establishes a nether opening—the anus. The remaining section of the primary tube on the ventral aspect of the notochord is known as the post-anal gut, represented in the adult by Luschka's gland, whilst the segment joining the ventral and dorsal portions of this primary tube is the neurenteric passage. All that portion of the tube on the dorsal aspect of the notochord anterior to the neurenteric passage becomes converted into spinal cord and brain.

Not only are the dorsal and ventral segments of the tube in connection by the neurenteric passage, but they are intimately associated in a way that is of some importance in support of my contention.

Occupying the flexure of the tubes is a chain of sympathetic ganglia which distribute branches to the ventral and dorsal sections of the tube. Those on the ventral portion of the tube ramify in the walls of the bowel, and are provided with intrinsic ganglia. These nerve plexuses are later recognised by the names of Auerbach and Meissner. Those distributed to the dorsal tube, ramify in its substance, and join with groups of nerve cells contained in the thickness of its walls, which constitute the essential elements of the grey matter of the cord.

A full and careful consideration of the facts briefly narrated in the preceding pages, has served to convince me that *the spinal cord and brain of vertebrata have been evolved from what was originally a section of the alimentary canal.* In other words, *the central nervous system is a modified piece of bowel.*

For convenience, the evidence in support of the view may be arranged in a series of paragraphs :—

1. The original continuity of the lumen of the gut and spinal cord.

2. The similarity in their mode of development and correspondence in point of time.

3. The relation of the lateral ganglia (sympathetic) to the walls of the gut and its intrinsic ganglia and to the ganglia (grey matter) of the cord respectively.

4. Each tube, the nervous and digestive, is protected by a serous membrane—in the one case the arachnoid, in the other, the pleuroperitoneal membrane.

5. In lower vertebrate forms the spinal cord is relatively larger than in man : in batrachians it much exceeds the brain in weight.

FIG. 3.—A COMBINATION OF SYRINGO-MYELOCELE AND MENINGOCELE—SYRINGO-MYELO-MENINGOCELE. (After Clutton, 'Trans. Clin. Soc.,' vol. xix.)

6. The association of certain malformations of the central canal of the spinal cord, especially *syringo-myelecele* and *syringo-meningomyelecele*, with malformations of the alimentary canal.

The last statement is of exceptional interest. Not long since, in dealing with certain forms of cysts, I ventured to state that, although we were absolutely in the dark concerning

the significance of the central canal of the cord, nevertheless, it was justifiable to regard it as an obsolete canal, that is to say, one that was functional in the ancestors of the present vertebrata, because, like such passages in general, it was extremely prone to take on cystic dilatation.

The general statement of the argument has not been overburdened with facts, my object being not to obscure the conception. Strange as it may seem to look upon the central nervous system as a piece of modified bowel, the metamorphosis is not more remarkable than many others that could be mentioned.

Many who suggest modes of evolutions are always most anxious to indicate particular roads along which the modification may be supposed to have travelled. If it were necessary, suggestions could easily be made on this head, but it would not advance my argument one jot.

Speculations of this character are rare in pathological science; nevertheless, they are as fascinating, and perhaps may be as useful, in this as in any other department of biology. If employed judiciously, they may afford guidance of no mean value, provided those who advance such views do not attach to them a concrete value. Pathology, I am sure, can be of service to biology, and general views may be suggested by a study of morbid, as well as by the consideration of normal anatomy.

Finally, it is by such methods as these that we may hope to found a satisfactory classification of many pathological conditions which, at the present time, are, for the most part, arranged in a vague, arbitrary, and meaningless fashion.