

## DEVELOPMENT OF THE OESOPHAGUS UNDER NORMAL AND EXPERIMENTAL CONDITIONS

A. BARCSA and L. MOHÁCSI

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Numerous authors have been concerned with the development of the oesophagus. The most detailed study has been published by SCHRIDDE [7], who examined in a large human material the development of the epithelial layer but paid no attention to the other elements of the oesophagus. Mention should be made also of the papers by KULLMANN [4], MOLLER [5], STIEVE [9], IVEY and EDGAR [3], who, although studying the problem in detail, examined one or another single layer of the oesophagus and ignored the interrelation between them, devoting no attention to the effect of function on morphological development.

We have undertaken to study the development of all tissue elements of the oesophagus from the earliest stage, the correlations and interrelations between them, with special reference to the effects of the environment and function on the formation of the morphological pattern of this organ. We studied the oesophagus during its embryonic evolution and in the second part of our study, we examined the effect of deglutition on the further course of histogenesis.

### Materials and method

First, chick embryos were studied from 75-hour stage till hatching. Each stage of evolution was examined daily by serial sections, of the results only those for the important stages will be mentioned concerning the part of the oesophagus above the crop. The finding concerning the part below the crop will not be discussed, because this section could not be influenced experimentally after hatching.

In the second series of experiments one-day old chicks were studied in three groups. Group one was fed on dry corn meal, group two on semisolid food, while the chicks of group three were operated on prior to feeding. The crop was incised, sutured to the skin and through the opening thus created a fine rubber tube was inserted. Through this tube the chicks were fed with raw eggs or with a mixture of raw eggs and powdered milk, first at two-hour intervals, then five times daily and later three times daily, increasing the dose with the advance of time.

The histologic findings of the oesophagus in the three groups were compared until the chicks had reached the age of two weeks. Considering that the most marked differences in structure were found between the chicks fed on solid food and those fed through the tube, these will be discussed in the first place.

## Results

In the four-day chick embryo the epithelium of the oesophagus consists of cylindrical cells distributed in 4 to 5 layers. The basal membrane is clearly visible and outside it mesenchymal cells can be found in loose distribution. At sites, a cuticula-like cell boundary is visible on the luminal surface of the epithelial cells. In this stage we also find segments in which the mesenchymal cells under the basal membrane are massed at a distance of about 60 to 80 microns and form the anlage of the tunica muscularis (Fig. 1), that develops later. Ciliated epithelium is found mostly in the lower segments.

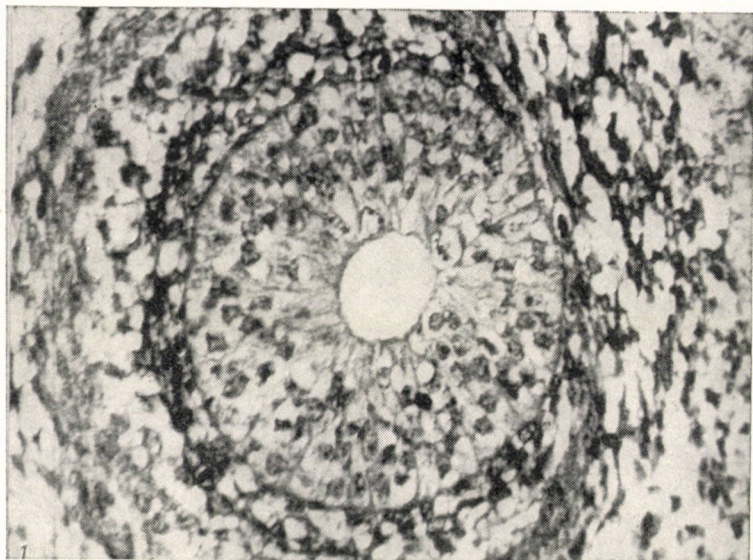
At the age of seven days the lumen of the oesophagus is still round or oval, lined in the lower portions of the superior segment with high cylindrical epithelium, covered at sites by islets of ciliated cells. In the upper segment the epithelial cells are cuboid in shape and at sites they create compartments in the lumen. The subepithelial mesenchymal cells that form a network represent the anlage of the submucosa. Peripherally, the continuous layer of the myoblasts with their elongated cytoplasm clearly signify the site of the circular layer of the tunica muscularis (Fig. 2).

In the ten days old chick embryo a significant change is observed. The circular muscle layer is much more differentiated and the muscle fibres appear to be functioning, as shown by the star-like shape of the lumen and by the changes in the epithelial layer. The latter is namely found to have more strata and is higher between the longitudinal folds than on the crest of the folds. This pattern becomes increasingly conspicuous on the 12th day (Fig. 3). It is at this time that the longitudinal myoblast layer begins to develop in the area corresponding to the muscularis mucosae, as well as outside the circular muscle layer. In the lumen of the oesophagus an acidophilic substance (suggested by many authors to be swallowed yolk) is found.

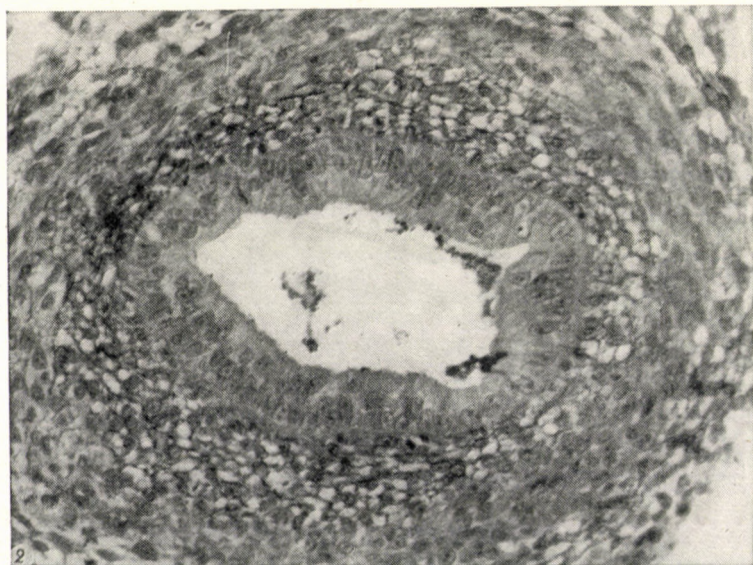
By the 16th day all the layers of the oesophagus have developed and it is at that time that the buds of glands begin to appear in larger numbers.

In the 19-day embryo we already see the typical, multi-layered, non-cornifying squamous epithelium (Fig. 4).

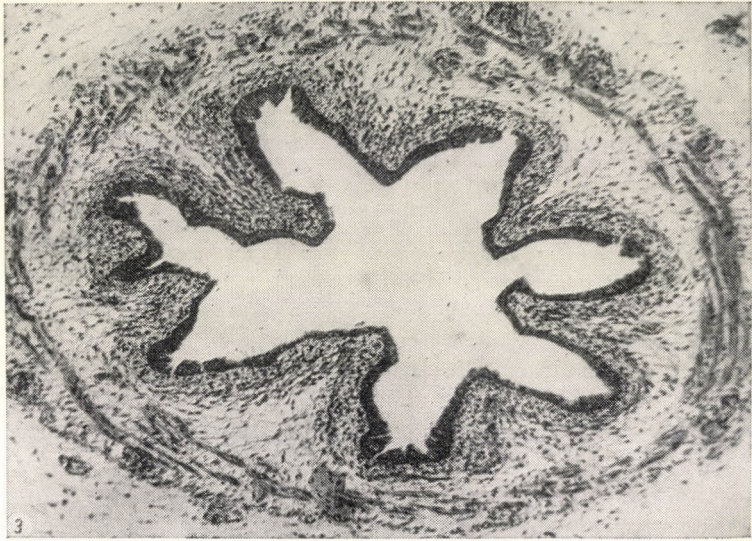
The observations made thus far indicate that the onset of deglutition (which is thought to begin on the 10th day) has a profound formative effect on the further development of the oesophagus. Only minor changes occur before the 9th day. Of all the changes taking place in every layer of the oesophageal wall it is the appearance of the circular layer of the tunica muscularis and the resultant star-shape of the lumen that are believed to be the most significant. That it is an active muscle function that is responsible for this pattern is indicated also by the circumstance that the thickness of the epithelial layer differs between the folds on their crest. At the same time there appears swallowed mucus in the lumen of the oesophagus. After deglutition has begun, the differ-



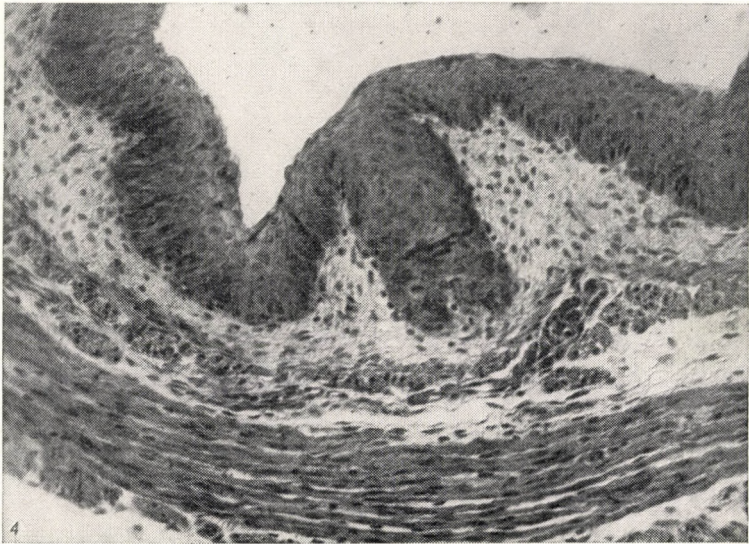
*Fig. 1.* Microscopic appearance of the oesophagus from a 4-day old chick embryo. Haematoxylin-eosin. Medium power view



*Fig. 2.* Microscopic appearance of the oesophagus from a 7-day old chick embryo. Haematoxylin-eosin. Medium power view



*Fig. 3.* Low power view of the lower third of the oesophagus from a 12-day old chick embryo. Haematoxylin-eosin



*Fig. 4.* Medium power view of the oesophagus from a 19-day chick embryo. Haematoxylin-eosin

entiation of the epithelium into squamous epithelium begins at first on the crest of the folds, these being most exposed to mechanical effects during deglutition. It is known from the literature that animals different in mode of life differ greatly in the epithelial structure of the oesophagus, depending on the kind and physical properties of their food (W. MOLLER, 1932; GOETSCH, 1910). These and other data in the literature, showing how great a formative action is exerted by mechanical effects and function, have induced us to influence experimentally the post-partum histogenesis of the oesophageal wall.

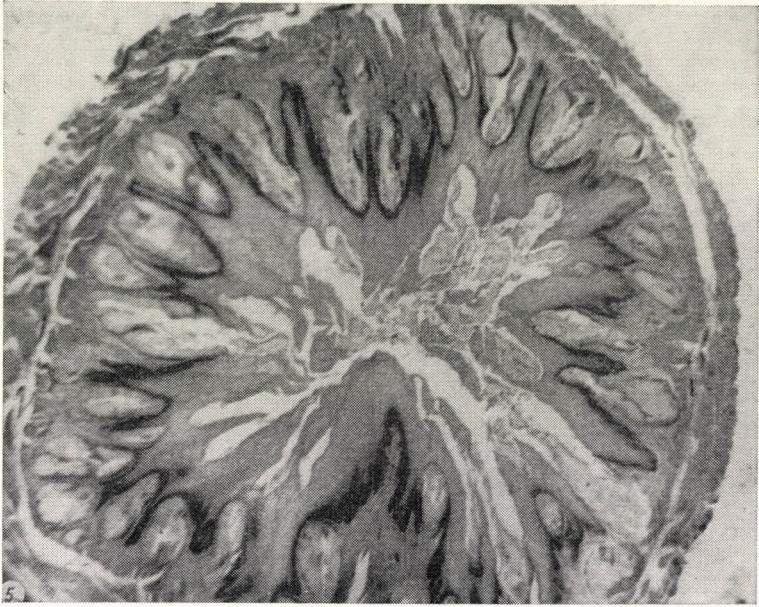
The results obtained for the operated and tube fed two weeks old chicken and those for the chicks fed on dry, solid food may be outlined as follows.

The oesophageal lumen in the tube-fed chicks is star-shaped, but considerably more distended than in the chicks fed on dry food. The epithelium consists of loosely grouped cells, arranged in about 6 to 15 strata. The cells are swollen, spindle-shaped, and those in the uppermost stratum are as high as those in the lowermost stratum. In the tunica propria simple glandular cells and chambers lined with flat cylindrical cells are visible (Fig. 5 and Fig. 7).

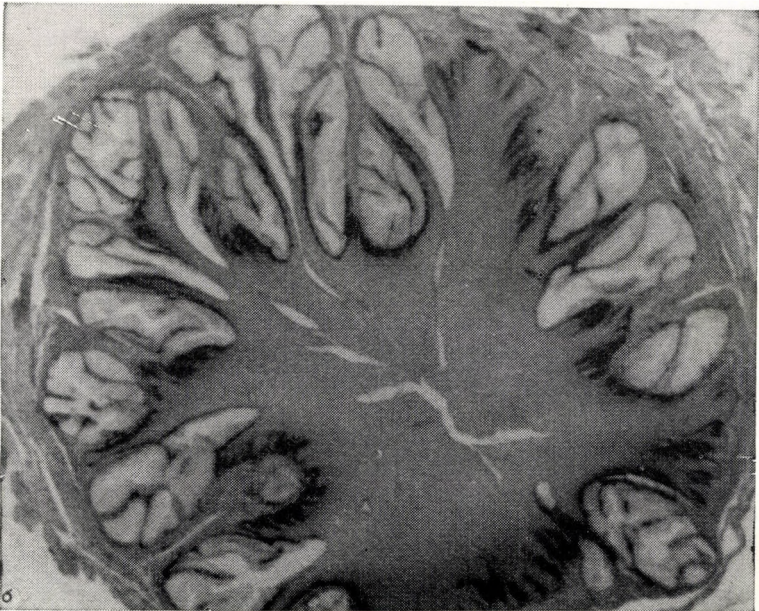
The lumen of the oesophagus in the chicks fed on dry, solid food for the same period almost disappears as a result of the strong musculature and the marked increase in the cellular strata of the epithelial tissue. The epithelial cells are densely packed, the cells are definitely flattened and as compared with the 6 to 15 strata, here we find as many as 25 to 30. The other great difference is in the glandular structure. The structure of the glands occupying the tunica propria as a whole is complex. The glandular surface is increased because the acini in the process of functional enlargement extend far into the connective tissue of the tunica propria, so that at sites one has the impression as if the papillae of connective tissue were embracing the gland as a whole. The glandular cells are high, filled with granules of secretion and the structure as a whole is indicative of intense activity. As opposed to the other group, here the submucosa is hardly visible, the enlarged glands extend to the circular layer of the tunica muscularis and occupy almost completely the submucosa (Fig. 6 and Fig. 8).

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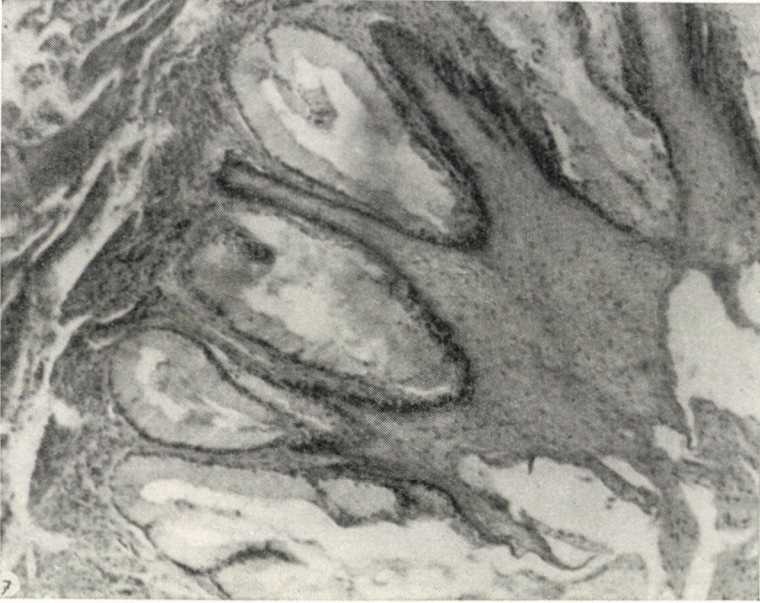
Summing up, in the tube-fed chicks, when the oesophagus had to forward only the excretion of the salivary glands, the structure of the epithelium was much looser, the epithelial cells less flat and the number of strata but one third of that found in the chicken fed on dry, solid food. In the latter the structure of the epithelium was also more dense, and the cells were much flatter. A great difference was found also in glandular structure. In the tube-fed chicken there were much less glands and glandular activity was less intense than in the chicken fed on dry, solid food, in which the oesophageal glands were well developed, occupied almost the entire tunica propria, had a complex structure and exhibited the signs of increased activity.



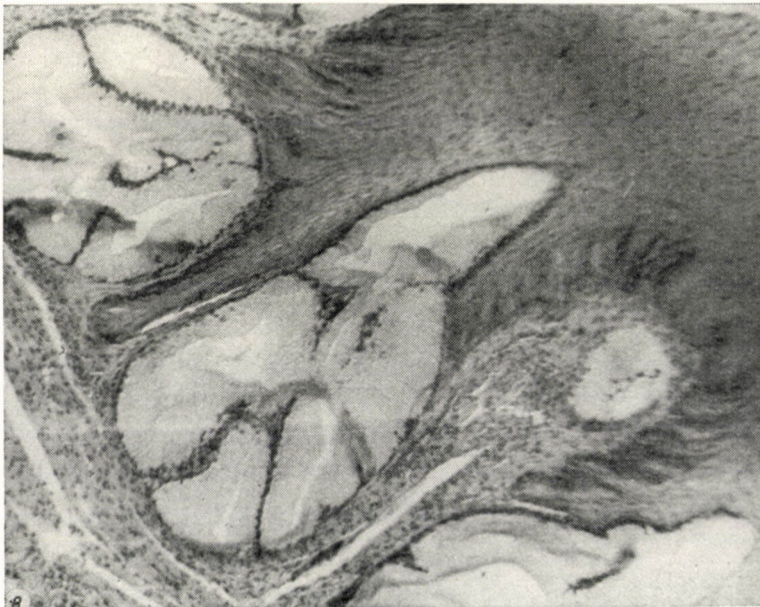
*Fig. 5.* Magnifying glass view of the lower third of the oesophagus from a tube-fed, 14-day old chicken. Haematoxylin-eosin



*Fig. 6.* Magnifying glass view of the oesophagus (lower third) from a 14-day old chicken fed on solid food. Haematoxylin-eosin



*Fig. 7.* Same as *Fig. 5*, high power view



*Fig. 8.* Same as *Fig. 6*, high power view

### Summary

The histogenesis of the oesophagus was examined in chicks from the third day of hatching till the onset of spontaneous feeding. The effect of the onset of function on the morphology of the developed oesophagus was also investigated. The chicken were fed on foods different in physical properties and one group was fed through a crop tube. It was found that on the ninth day, when the circular musculature has developed and presumably deglutition has begun, the structure of the oesophagus suddenly changed, with conspicuous changes in the epithelium.

The second change takes place when spontaneous feeding begins. Subsequently the physical properties of the food are influencing the morphology of the oesophagus. In the tube-fed chicken there are only 6- to 15 strata of epithelial cells, the cells are round, the glands underdeveloped, the muscles weak. As opposed to this, chicken fed on grain have 25 to 30 strata of epithelial cells, the cells are flat, the glands are about four times as large as in the former case and the muscles are strong.

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### СТРУКТУРНОЕ РАЗВИТИЕ ПИЩЕВОДА В НОРМАЛЬНЫХ И ЭКСПЕРИМЕНТАЛЬНЫХ УСЛОВИЯХ

А. БАРЧА и Л. МОХАЧИ

Авторы исследовали развитие пищевода у цыплят, начиная от трехдневной инкубации до начала самостоятельного питания, а также то, какое действие оказывает начинающаяся функция на уже оформившийся пищевод. Исследовались изменения, которые вызываются кормлением пищей различных физических свойств, и изменения, происходящие в пищеводе цыплят, кормленных через зобный зонд, не получающих ни пищи ни питья через рот. Авторы установили, что структура пищевода на девятый день исследования — когда развивается круговая мускулатура, и, предположительно, наступают также глотательные движения, претерпевает внезапное изменение, которое прежде всего выявляется на эпителии.

Начало самостоятельного питания вызывает второе большое изменение, которое формирует структуру пищевода в соответствии с физическими свойствами корма. Эпителий кормленных через зобный зонд цыплят имеет толщину только 6—15 клеточных рядов, эпителиальные клетки более кругловатые, железы недоразвитые, мускулатура слабая. В противоположность этому эпителий пищевода цыплят, кормленных зерновым кормом, состоит из 25—30 клеточных рядов, эпителиальные клетки сплюснутые, железы по сравнению с вышеуказанной группой развивались до 4 кратного размера, а мускулатура укрепились.



## DIE GEWEBSENTWICKLUNG DER SPEISERÖHRE UNTER NORMALEN UND EXPERIMENTELL BEDINGUNGEN

A. BARCSA und L. MOHÁCSI

Die Entwicklung der Speiseröhre ferner die Frage, welche Wirkung die beginnende Funktion auf die in Entwicklung befindliche Speiseröhre ausübt wurde an Hühnerembryonen, von dreitägiger Inkubation bis zum Beginn der selbstständigen Ernährung untersucht. Untersucht wurde gleichfalls, welche Veränderungen mit Futterarten von verschiedenen physischen Eigenschaften herforgerufen werden und wie sich die Speiseröhre von ausschließlich durch Kropfsonde ernährten Hühner gestaltet.

Es wurde festgestellt, daß, da in der Struktur der Speiseröhre am neunten Tag, als sich die zirkuläre Muskulatur bereits entwickelt hat, und auch die Schluckbewegungen aller Wahrscheinlichkeit nach begonnen haben, eine plötzliche Veränderung eintritt. Diese Änderung ist vornehmlich am Epithel augenfällig.

Der Beginn der selbstständigen Ernährung bedingt die zweite große Veränderung, die die Struktur der Speiseröhre, in Abhängigkeit von den physischen Eigenschaften des Futters, gestaltet. Das Epithel der mit Sonden ernährten Hühner besteht aus 0—15 Zellschichten, die Epithelzellen sind eher rundlich, die Drüsen unentwickelt, die Muskulatur schwach. Hingegen besteht das Epithel der Speiseröhre von Hühnern, die mit Hartfutter gefüttert werden, aus 25—30 Zellschichten, die Epithelzellen sind abgeflacht, die Drüsen erreichen im Vergleich zu der vorigen Gruppe eine vierfache Größe, und die Muskulatur ist kräftiger.

Dr. András BARCSA }  
Dr. László MOHÁCSI } Debrecen, 12, Anatómiai Int. Hungary