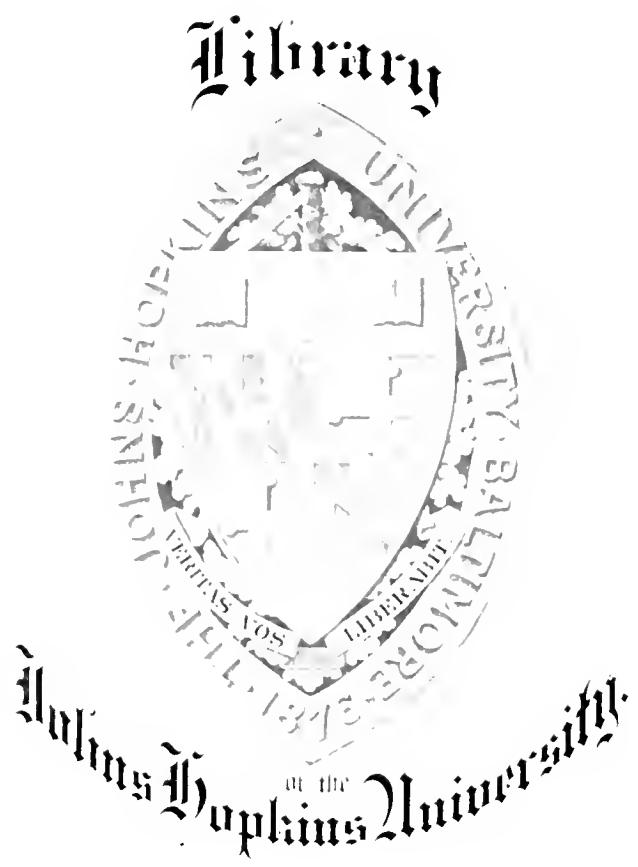
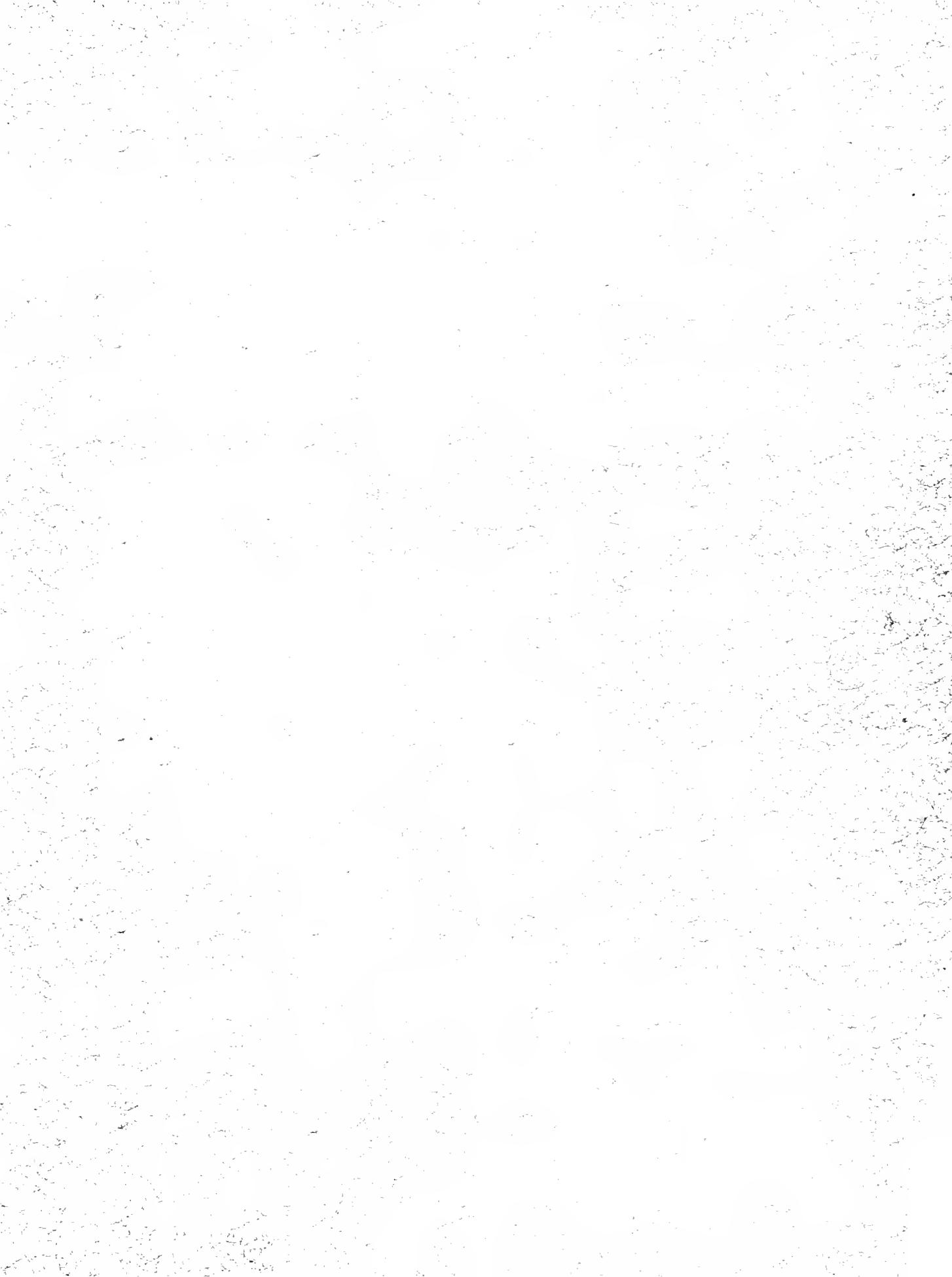


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Johns Hopkins University



Stability Constants of the Thyroid Gland

J. P. DIBBLELL.

I am honored to submit to the Board of University
Studies of the Johns Hopkins University, for the
degree of Doctor of Philosophy,

the

ALKALI METAL STABILITIES

IN THE HUMAN THYROID

1920.

STRUCTURE AND DEVELOPMENT OF THE THYROID GLAND
IN PETROMYZON.

THOMAS MCKEEAN.

The first lot of material for this work was obtained from Prof. E. L. Moulton, of Cornell University, who sent me a lot of material from his work on the development of the thyroid gland in *P. planiceps*. This material was obtained from a female which had just given birth to a lot of young. The first lot of material was obtained from a female which had given birth to a lot of young. It included eggs from which larvae had hatched, and the swimming larva in which the thyroid could be clearly seen, a small, visible and in which the mouth was surrounded by a ring of skin only a thin partition of skin. This older stage was killed fourteen days after fertilization.

The second lot of material was obtained at Ithaca, N. Y., from Prof. H. L. Clark, of Cornell University, Wilder (Lake lamprey) and *T. maculatus* (Brook lamprey), as both species are known to spawn in the same nest and it is impossible to tell to which species the larvae belong. Part of this lot of material was sent me directly by the courtesy of Prof. S. M. Gage of Cornell; the rest I myself obtained from one of the "nests" in a stream at Ithaca, New York.

Det. location of N. solid plan in Petrom. zon.

The specimen was found in the Petrom. zon., as follows: -
The specimen was found in the vertical wall of
the well, which is called the pha-
rynx, and it is connected by openings connecting
it with the body cavity. The first found,
in ~~the~~ P. ~~.....~~, is old, that
is to say, it is not broken
and can be seen in
Fig. 2. The ~~.....~~ shows the condition of gill-
like structures, which are not broken
but are still in their original mass at the
posterior part of the neck. In the figure, the
gill-like structures are shown forming the
cervical fold, which is represented
as a series of shallow curves, the second of which is
seen to be slightly older stage,
the last cervical fold is the youngest, and is seen as a series
of shallow curves, which are situated in front of the neck
of the flask.

The thyroid gland, on the anterior end, is broad and
deep, so that, with its thick walls, it is half as large, in
cross section, as the part of the pharynx from which it is de-

lived. The lateral walls are, throughout the length, very thick, and are composed of a layer of small, elongated cells, each cell with a nucleus situated near the centre. The ventral wall is thin at first, and becomes progressively shorter, even evanescent, as the animal grows.

As the animal grows, the ventral wall, if it is found to become evanescent, continues to grow until it is shallow until it fills the body cavity.

At the time of hatching the animal, older stage, the thyroid is a simple, thin-walled sac, situated through the mid-dorsal groove, and has a somewhat trilobite appearance as an evagination of the body wall (Fig. 10). The thick lateral walls of the body cavity and thyroid are shown in this figure. In the same figure, the gut formed in this sac is shown, and the anterior end, or foregut, is the posterior to the thyroid, and the hindgut, or rectum, gradually becomes more and more distinct from the body cavity.

The thyroid, at this early stage, is a groove, relatively deep, situated dorsally, opening anteriorly, and opening along the ventral mid-line, in the body cavity.

(100 days.) At the middle day, the thyroid begins to be shielded from the above cavity by growth of two horizontal partitions, one roofing over the anterior end, the other roofing over the posterior end, of the thyroid groove.

The thyroid gland is shown to a slightly greater extent in the section through the body of the hyoid bone. At this stage the thyroid al-
ready consists of two lobes, which are situated on the medial
surface of the body of the hyoid bone. The anterior lobe (a. b. l.)
is larger than the posterior lobe (p. b. l.), which is
just half as large. The body wall of the thyroid
consists of a thin layer of connective tissue, which is
represented in the figure by a dotted line. The remaining
part of the body wall is represented in
the figure by a solid line. The median plane is shown
in the figure as a vertical line in the middle of the groove.
The anterior lobe is situated in front of the body wall of
the thyroid. In the figure (fig. 10), the first indication
of the thyroid is seen in the median plane of the pharynx
(fig. 10). A transverse
section of the pharynx at the anterior end of the
thyroid shows (fig. 11) that it is now
a clear, well-defined, oval-shaped, body just beneath
the epipharyngeal membrane. It is covered throughout
by a thin, smooth, mucous membrane, which contains numerous
small papillae. The body of the thyroid is surrounded
by a thin, smooth, mucous membrane, which will be the later
epipharyngeal membrane. The body of the thyroid is not so sharply
differentiated from those in the roof of the pharynx as is

In the *Potromyzon* embryo the cells of the body wall are very abundant in the region of the pharynx. In this part of the body wall the epidermis is thin and the underlying mesoderm is thick. See Fig. 1 b. The epidermis is represented by a solid line and the mesoderm by a dotted line. The epidermis passes through the part of the body wall which is adjacent to the pharynx. In the epidermis the cells are solid, while in the mesoderm they are dotted. The epidermis is very thin at the beginning of the thyroid development and the thyroid being developed is very large. The rapid growth of the anterior end of the thyroid causes the rapid growth at the points where it comes in contact with the anterior epithelial fold. This causes the anterior epithelial fold to thicken, causing these two folds to meet in the middle. The middle layer of each fold is composed of the anterior epithelial fold and the basal epithelium, the latter being the basal layer of the thyroid (Fig. 1 b). The basal layer of the thyroid, which is still epithelial, is evaginating to form the thyroid. As is seen in Fig. 1 b, the basal layer of the thyroid is closely pressed against the anterior epithelial fold, but it is difficult to find any connection.

It will be interesting to compare the *Potromyzon* thyroid at this stage with the thyroid at a corresponding stage in *Ambystoma* (Figs. 9 a and 9 b). A section through the

The figure of the Petromyzon Apterygoid (Fig. 1².) shows it
as though the oesophagus were closed; it is still an open
tube (Fig. 1³), but on the other hand, the opening
is so small that it is almost closed, the closing
being effected by a thickened band in the median direction.

When the thyroid is removed, at the same time the lateral
walls of the oesophagus are drawn to the anterior end,

but if the thyroid is left in place, the walls of the oes-

ophagus are drawn to the anterior end at the same time an

area of the mucous membrane is drawn to the anterior end in a longitudinal

direction, so that the two lateral walls of the gland

(Fig. 1⁴) are much more markedly thickened in the median

direction than the lateral walls of the thyroid.

If the thyroid is removed, the oesophagus would show

the same condition as the lateral and ventral walls

(Fig. 1⁵), but if the thyroid is left in a wax re-

construction, the condition of the oesophagus in sections of

thyroidless specimens is very similar to that of the anterior end of the gland

of the intact specimen, the mucous membrane being thick and solid. The two

lateral walls of the oesophagus are drawn to the anterior end by the mesoblast

of the thyroid, so that the two lateral walls are close together and the sepa-

ration extends only a short distance from the anterior end of

the gland. The thyroid is not so closely pressed against

The glandular tissue is the case in previous sections, being separated from the wall of the cavity by a collection of mesoblast cells. The anterior wall of the cavity is broad and is crescentic in cross section, while the posterior wall is long and the lateral walls are narrow.

The anterior wall of the cavity is not for about 2/5 of its width smooth, but is rounded and irregularly, so that its open end is somewhat like a funnel extending only 1/5 of the distance.

The cavity opens into a large, irregular, oval-shaped area (Fig. 2 A, m.l.) which is bounded on the right by the thickened dorsal wall of the cavity, and on the left by a small, circular cavity of the ventral wall (Fig. 2 B). This is produced, by the growth and separation of the two walls, as a narrow vertical slit with lateral lips which close the cavity. Along the cavity, in cross section, there is a slight median elevation (Fig. 2 C). The dorsal wall of the cavity (Fig. 2 D, Fig. 2 E) is comparatively thin, being composed of a single layer of short columnar cells, and is what Dohrn calls "the neckless type." The ventral wall is also comparatively thin, and shows in the center, at the extreme anterior end of the unpainted cavity, a slight upward projection (Fig. 2 B, m.l.) which would seem to be the first indication of the medial longitudinal partition that will later divide the gland into two lateral parts. According to Dohrn, this me-

distal lamella is formed as far back as the opening of the gland, before the lateral invagination takes place, but in my material this is certainly not the case, as is shown in Fig. 2 b.

The lateral invaginations extend posteriorly to a point a little behind the anterior edge of the slit-like opening into the pharynx. The section from a section that cut through the extreme posterior part of the invagination in the right side but was too far posterior to cut through the left side, either because the section was extremely oblique or because the right invagination had proceeded further than the left.

It will be seen a clear idea of these lateral invaginations in the simple condition represented in Fig. 2 b, as the more complicated later stages will then be more easily understood. As the distal walls disappear first, thus obliterating the lateral invaginations, the thyroid would be reduced to a more or less cylindrical form, as it was in Fig. 1 b, though with a much larger cavity. The former walls of the lateral walls are divided by the invagination into two groups, which become more and more distinct as fetidolete proceeds. In Fig. 2 b one of these rows, on each side, lies between the invagination and the perpendicular part of the cavity of the gland; the other group lies between the invagination and the dorsal, horizontal part of the cavity (compare Fig. 3 e). The cavity of the thyroid between this point and the posterior edge of the opening into the pharynx is simply a deep and narrow groove, slightly

where obtained
from ~~T. poecilum~~
~~and the larvae~~
will be remembered, 2.
were one in? b.
as identical with
the ~~adult~~ ~~larva~~ of ~~L.~~
and the ~~adult~~ ~~larva~~ of ~~L.~~
is the development of the thyroid gland
which is developed in the middle (Fig. 4 a,
m.e.) which is rapidly increased on the thin dorsal
and ventral walls, beginning at the anterior end and gradually
extending posteriorly until, at this stage, the gland is separated

into two distinct lateral parts, from the anterior end about half way to the opening into the pharynx. Fig. 4 a is a section through the junction of the anterior and middle partition, showing the layer of mesoblast and the meso-lamelle. The once simple ciliated layer has disappeared, and the surface of its walls. The surface of the epithelium shows the "lateral invaginations" (L.I.) which are the result of a dense-median differentiation, and the latter is best seen in Fig. 2 b. The changes in the mesoblast are evident in the roof and floor of the pharynx, where it is divided into two halves, thus separating the mesoblast from the meso-lamelle. At a later stage the mesoblast becomes differentiated into meso-lamella, meso-epithelium, and meso-cells, and contains numerous rounded cells, and containing cilia on the outer surface. This is at this time also the beginning of the development of the "Pseudochloridia," which are small, rounded, vacuolated bodies in the floor of the pharynx. The next figure (Fig. 4 b) is a section from the opening of the gland (Fig. 4 a, b, c, d). At this stage no cilia could be seen, and the body was much smaller than it was at later stages of development. The cavity of the gland, in the region represented in Fig. 4 b, will contain, in a cross section, its resemblance to the latter T. This section is anterior to the duct, but posterior to the median lamelle represented in Fig. 4 a. The other changes noticed at this stage are :- the closing of the

(v.), and the circulation of the blood through the bronchial vessels can be seen easily under a low power. The thyroid, situated just above the pharynx, is large in all the animal, shows very dark granulations. The rectal sac and the oesophagus of the pharynx are well developed. The mouth is large, and the blood dotted lips are well developed. There is no indication over the mouth of any sensory nerve endings. In the older larvae (e.), no attempt has been made to indicate the various regions of the larva.

A transverse section of a larva of this age shows the thyroid situated dorsally, and the rectal sac situated ventrally against the ventral wall of the body.

The first section was made in the left veliger region, and the second in the bell groove. Fig. 5 b illustrates the position of the rectal sac relative to the thyroid. The rectal sac (rect.) (Fig. 5 a and 'c.'), body wall (c.m.), and the right side of the pharynx (phar.) are shown. The rectal sac, a small vesicle, passes through the ciliated groove of the pharynx, and turns anteriorly-directly ventral (arrow 'a'). It then runs dorsward to run parallel to the dorsal margin of the body (arrow 'b' left). On the left of the rectal sac two longitudinal grooves are distinct near dorsal (dors.) and ventral (vent.) rows. These grooves are lined with cells which appear more elongated and more columnar than the cells of the rest of the pharyngeal wall, so that they are easily followed, by sections, throughout their course.

Whitfield's *Scutellaria* is a good example.

opening into the buccal cavity, are continued on the floor of the pharynx as a ridge, a fillet, similar to *uvula* (Figs. e, j-k), which will often be seen upon the floor of the pharynx as a groove, which is called *groove of the fillet*. The ridge of thickened epithelium. The cilia on the ridge of the fillet of the pharynx may be lost by age, but the ridge itself, and the groove may be seen plainly. The groove of the fillet of the pharynx may be seen plainly with a lens. The groove of the fillet of the pharynx is formed by a ridge running from the dorsal ciliated epithelium, and the ridge can easily be made out.

The grooves of the pharynx, which are called *gill-grooves*, showed the following arrangement. On the floor of the pharynx the arrangement could be observed as follows: first, the groove of the fillet; second, all grooves is quite different, and third, the groove of the gills. In an interesting book "Anatomia del Cefaloide" (1875) on page 163 it is written: "In the pharynx there are two rows of cilia in front of the gills. The first row of cilia is situated in the first gill-grooves, and then proceeds to the second gill-groove, and so on along the dorsal midline of the pharynx, and the second row of cilia is situated in the oesophagus. The middle of the second row of cilia is situated in the oesophagus, and uniting together, forms a ridge, which is called *fillet*, and above to the posterior edge of the gills." The arrangement of the grooves of the pharynx is believed to be as follows: On the floor of the pharynx, beginning at or near the opening of the oesophagus, is a ridge of epithelium on which no cilia could be made out. This ridge,

the arrangement of the gill-grooves in the grooves

then is believed as follows: On the floor of the pharynx, beginning at or near the opening of the oesophagus, is a ridge of epithelium on which no cilia could be made out. This ridge,

after extending forward for a very short distance, becomes changed gradually into a shallow, median, ciliated groove that continues anteriorly to the anterior of the thyroid. Just anterior to this the groove divides into two grooves which run posteriorly to the pharynx, one on each side to the ventral surface of the body. These grooves then converge posteriorly and finally meet in a median ciliated groove which lies near the front end of the thyroid. This median, ciliated, median groove is the beginning of the oesophagus, of which it forms the first 15 mm. of the muscular wall.

The next stage of development is shown in previous chapters, the changes being as follows. The cover cells (Fig. 5, e, i.v.) have increased in number and are now crowded until they now completely cover the entire organ. The anterior lamella (Fig. 5, e-f, m.l.) has increased in size and is now near one end. The anterior lamella is situated between the median lamella (Fig. 5, e-f, m.l.) and the lateral lamella. The latter is the largest and is situated on the floor of the glottis but is very thin. The glottis is now being swollen for a considerable distance behind the mouth (Figs. 5, i-k, m.l.). The lateral lamella is very large and important in determining the structure of the organ. Here the anterior end (Fig. 5, e, i.v.) it has not changed greatly from the condition

in which it was at a late stage, but as we pass to sections further back the first sign of the invagination forms a considerable cavity in which the glandular epithelium (Fig. 5, f-h, i.v.), and particularly the ciliated layer, is seen to be displaced. This cavity, which is roughly oval and two lateral invaginations have been formed in the body of the invagination, is shown in Fig. 5, g, i.v., and Fig. 5, h, i.v.).

The next stage is reached in the following stages that have taken place in the development of the invagination. The first among the changes is the separation of the outer layer of those cells into two groups, one of which becomes the basal cells proper. The outer group of cells is shown in Fig. 5, e. As can be seen in the figure, these basal cells appear to have become somewhat flattened and to form a somewhat oval area of cells. The boundary of this oval, as is evident, by the lateral invaginations, is formed by the outer edge of this oval mass of cells. This boundary is the basal layer (n.g.l.), is seen to consist of columnar cells, and the outer part (n.g.l.) apparently having become somewhat flattened is the ciliated layer (c.l.). The nucleus in the basal cells is seen to be absent columnar cells (Fig. 5, f, g, h, i.v., and Fig. 5, i.v.). The cavity formed in the gland cells proper (Fig. 5, f, g, h, i.v.) is connected with the lateral invagination (Figs. 5, f-h, i.v.) by the separation, in the centre (at the end of the line n.g.l., Fig. 5e)

of the nuclei of the 1st row (n.g.l.) and the joining of these separated ones with the nuclei of the adjacent sides of the interdigitations will form a chain-like cells above (dorsal to). After which the 2nd row of nuclei will pass above the interdigitations. This will give rise to the (posterior to) n.g.l. joining of the 2nd row of nuclei and the continuation. In other words, the 1st row of nuclei will form the epithelial cells and the 2nd row of nuclei will form the mesoderm. Particularly the breaking away of the 1st row of nuclei at the end of the segment of the 1st row will give rise to the imagination. The first 2 rows of nuclei are represented by dotted lines, referred to as the primary germ layers, and the 3rd row of nuclei.

On account of the great difficulty in obtaining good preparations of these gland cells, as before mentioned, many series

of sections had to be studied before any conclusion could be reached as to the minute structure of the cell groups. The pointed ends of the cells and distinct rounded citoplasmic (c.) of the cells, which are usually found in the basal portion of the cell, are usually obscured by the nucleus. In the basal portion of the cell there is, however, a small amount of cytoplasm which practically every instance of the cell group is found. The amount of citoplasm of the cell group may be so limited that it is difficult to see. There was no secretion found in the basal portion of the cell group. This fact could be easily determined because the basal portion was carried over, as shown in Fig. 61. The cell group may be identified by the nucleus which is located in the center of the cell group, may be followed along the outer side of the cell group, and the nucleus of each section, it is difficult to see. It is also difficult to see the outer side of the cell group because the outer surfaces of lobes in the nucleus, the plasma membrane and the basement, are too minute to be seen, this means that magnification of 1200 diameters.

In Fig. 61 may be seen, just under the basement mem-

lateral, a number of triangular condensations of the cell substance on each side of the oesophagus. These epithelial cells were seen in the gut of certain larvae. It is possible to be stained in such a way that they will appear in the gut. Their presence suggests a glandular origin.

It is evident that the epipharyngeal gland may be considered to consist of two parts. One part is a large and two small cylinders situated on each side of the oesophagus along the whole length of the gut. The large cylinder is about 1 mm. in diameter, the small cylindrical ones about 0.5 mm. in diameter. They can scarcely be distinguished from the surrounding epithelial cells until they acquire lateral processes which connect them to the oesophagus. The larger cylinders have a ciliated surface, while the smaller ones a non-ciliated surface. The secretion of the epipharyngeal gland passes through the oesophagus and thence, through the gut, to the mouth and into the pharynx.

The epipharyngeal gland of the adult female gland may be described as follows. The body of the epipharyngeal gland is somewhat complicated, consisting of a number of small tubules. A ventral branch-cess of the oesophagus passes through the body of the pharynx, separating ciliated and non-ciliated epithelium and form a single layer process (Fig. 2, 3, 4, 5, 6, 7, 8, 9). In Fig. 7 the ventral ciliated processes (v.c.p.) have almost united, being separated only by a wedge-shaped portion of the pharyngeal floor.

The grooves are deep and so narrow that there could seem to be but little room for ciliated cells. The cilia lining the grooves are however numerous and the other cells of the pharynx, which are not ciliated, are said to be the ordinary epithelial cells.

On the right side of the groove, and one side only, of the lumen, there are three rows of three fourths ciliated cells, and the remaining one fourth of the cells (d.l.) are not ciliated. They are all ciliated on the other.

These cells are similar to those described previously from a specimen of *Thalassophryne* (B. & K.). They are ciliated, irregular in form, and are very irregular in size. A cell of this type has been described by Wiedemann (1867) as having basal ends to the sides of the nucleus, and a long process of projection (i.v.).

Surrounding the groove are two rows of small, rounded, lying close together, ciliated cells. These are the thyroid cells. Before reaching the groove they are arranged in a single layer, but as they approach the groove they are arranged in two layers, and resemble, in cross section, oval or circular cells, the bases of all the T turn upwards and are closed off (Fig. 42, 43, 44) until they are closed against each other to form a ring. The way in which this curious arrangement, finally, into the thyroid is interesting. A short distance back of the point represented

In Fig. 5 i, the colliculi of ciliated and cover layers are indicated by the small black dots (Fig. 5 i, 1) and at the junction of the two layers (Fig. 5 i, 2) becomes a single layer of ciliated columnar cells (Fig. 5 i, 3). (Fig. 5 h).

At the point where the ciliated layer ends (Fig. 5 i, 4), the ciliated layer becomes a simple layer, and at the junction of the two layers (Fig. 5 i, 5) we have a single layer of ciliated columnar cells (Fig. 5 i, 6) off the cover layer. At the junction of the two layers (Fig. 5 i, 7) of the gland cells (Fig. 5 i, 8) and the ciliated layer (Fig. 5 i, 9) (Fig. 5 i, 10), the ciliated layer becomes a simple layer.

From the above description of the section passing through the secretory gland, we see that the secretory duct (Fig. 5 i, 11) passes out of the gland (Fig. 5 i, 12) through a transition group (Fig. 5 i, 13) of ciliated columnar cells (Fig. 5 i, 14) and thence divides into two branches (Fig. 5 i, 15) leading to the secretion from the acini (Fig. 5 i, 16). The secretory duct passes through the ciliated epithelium (Fig. 5 i, 17) and the epithelial chambers (Fig. 5 i, 18) and leads to the surface (Fig. 5 i, 19, 20). The secretion from the different chambers can be excreted either way. The duct is ciliated and runs a postero-inferior direction and is lined with ciliated columnar cells. The point at the end of the line 1 (Fig. 5 i) indicates the place of union of

of the medial part (Fig. 5 h, 1) of the ciliated layer with the adjacent side (1') of the deep, ciliated groove (v.e.g.). Reference line 2 connects the lateral part (2) of the cover layer joining the ciliated (2') and non-ciliated portion (2''). Reference line 3 indicates the junction of the medial part (3) of the ciliated layer with the lateral part (3') of the ciliated duct (l.d.). Reference line 4 indicates the union of the two parts of the ciliated layer which complete partition all the mesoderm of the glandular region.

The ciliated layer (1) of the glandular medial portion (2) of the epidermis is continuous with the opposite side, above the medial ciliated layer (2') of the lateral part (3) of this layer and with the lateral part (3') of the cover layer. The epidermal layer (1) of the glandular (l.v.) apparently complies with the ciliated (2) and non-ciliated (3) part of the epidermis of the glandular duct (l.d.). The mesoblast cells are found just below the epidermis (line 1) and is shown also in Fig. 5 n, under the epidermal portion of the salivary gland. A section of this epidermis (line 1) and (2) has the lateral invagination (l.v.) which completely separates the lateral from the central portion of the gland, but if cutted off the section were cut nearer to the dorsal surface of the gland, the lateral portion would be seen to be joined to the central portion anterior to the duct (to the left of m.l.), as has been seen in

Figs. 6-8. Fig. 6 shows the extent to which the gland is completely divided by the partition (m.l.), and also the position of the ciliated surface in the middle (v.c., 2-5). The cilia are ciliated throughout the gland. In all the sections posterior to the 2nd, the cilia are visible, and in some there distinct ciliated chambers. The second ciliated portion (m.c.), occupying the dorsal midline of the gland, is wider also in cross section, and its position is indicated by the cilia on the median lamella (m.l.) which extends across the middle of the ciliated wall. Into each half of the median ciliated portion comes one of the large and two of the small groups of ciliated gland cells. The smaller will be seen to be ciliated, while the stage is still in a median ciliated gland.

The lateral ciliated portion (l.c.) is crescentic in cross section, the lower or ventral part being formed by the ciliated cilia, the upper or dorsal by the cover cells. Into the lateral ciliated portion large and small group of gland cells. Dorsal to the l.c. and near the two blood vessels (art.) and place above these is a layer of connective tissue, with the ventral ciliated portion (v.c.), now more advanced in depth. Fig. 6 k is of a section near the posterior end of the gland, passing through the unciliated portion. The reference line m.c.h. begins in the cavity of this unciliated part, which is cut through at the point where it is continuous with the central ciliated chamber of the gland. A section just anterior to this

would show this upper space or a separate cavity. Dohrn says this marked bend at the glottis is said, as well as the less marked one, to be the result of pressure, i.e., caused by the growth of the gland itself, which is situated just above the epiphysis which it is enclosed.

The first figure of the second stage shows the point represented in Figure 10. The mesodermal and endodermal partition (m.l.) is still present, but has become somewhat atrophied at m.l. 1. At this stage the dorsal (dorsal) and dorsal ciliae (cilia d.) are still present, but the ventral (ventr.) and ventral ciliae (cilia v.) have disappeared. The body is 5 mm. long, 5 k. The blood vessels are well developed, and the heart is filled with large, nucleated erythrocytes. The epiphysis is 5 mm. (Figs. 5 k and 6 l), and the epiphysis is about 1 mm. in diameter. The arrangement of the gland cells has changed so greatly that they are no longer organized in rows. The lateral ciliae are now absent, leaving only circular cavities, and the ventral ciliae are still present, spreading out gradually, suspending the epiphysis. This condition is mentioned in the description of the first stage of development. The ciliated dorsal ridge is very prominent, and is folded back to the sorta in its folds. The cell structure of the epiphysis is well shown in most of the photomicrographs, and in Figures 5 and 6 of the preceding figures.

In the following and last stage of development (Figs. 9 a-k), the gland has apparently reached its greatest complexity,

and only noticeable change from the preceding all mouth young is that, except for a few fine hairs, the membranous ceiling of the pharynx is now filled up with a thin, pale, fleshy mass which has been previously described. The gland itself is now about 1/2 the size of the gland before it was cut off, but is still 1/2 to 2 mm. in diameter. The long axis of the gland is about 1/2 the normal size, or a length of about 11 mm. and it terminates in a blunt point just in the region of the glottis.

The figure shows the anterior and posterior end of a larva of *Thraupis sp.* (L.) (about 10 mm.) of which his entire body is shown. The figure is drawn to scale and is drawn to each side of the body. The figure shows the anterior end of the body, the head, the gape, the nostril, the eye, the posterior end of the gland, the rectum, the cloaca, the泄殖腔, which lies close to each side of the rectum, and the entire length of the gland. The rectum, the cloaca, the泄殖腔, and lateral invaginations (gill, gill, gill, and gill) are covered with a thin, solid mass of white, fat-like-looking connective tissue which completely encloses the gland on all sides. At this stage, as in the all mouth young, the gland extends from the middle of the first to the middle of the fourth all pouch (g.p.) and is about 1/3 the diameter of the entire pharynx.

In a ventral view, the coil of the posterior end of the gland was cut, of course, short, but at each end is seen a median groove which allows small vessels to diffuse envelope; these vessels are easily followed back to the parts of the gland, and no difficulty is experienced in the first two-thirds of their length. Following these vessels, the gland is followed. The numerous tubercles of the anterior wall of the glandular ducts are seen in this manner. The first section of the anterior wall of the glandular duct is shown in the figure. The second section is also shown.

The first section of the anterior wall of the gland, to which reference has been made, was cut, and also to follow later, and it is the first section of size and position of the glandular ducts. It is reconstructed and drawn by hand. In this drawing, more or less accurately, the anterior wall of the gland, which lies a little behind the glandular ducts, is drawn. The gland, though in this hand-drawn diagram, is not quite right, is enlightened out, and the anterior wall of the gland is drawn at its anterior end.

In comparing this with the original drawing, it will be noticed that the tract of the anterior wall of the gland is instead of a nearly circular duct, a large irregular one, and apparently not having any place for the renal papillae. This, of course represents the actual relative longitudinal and transverse dimensions of the duct. The actual increase in size of the gland may be appreciated by noting that, though all the sections were drawn with a camera,

those represented in Fig. 8. b-1 are enlarged 240 diameters, while those in Fig. 8. c-1 are magnified only 30 times.

The cells, while at other places there is no apparent regularity, are all in arrangement. In Fig. 17, the small cells with large nuclei are arranged in bands of 3-5 cells, filling the cleft-like openings (c.) into the muscle of the oesophagus. The ciliated tracheas (v.c.e.), at the junction of the bands of small cells, are filled from distance 2,000 to 3,000 microns apart, and the distance is little changed from their original position of 1,000 microns. They are separated by one large and irregular cell in the floor of the pharynx, which seems, from its position, to be the first in outline, probably anterior to the ciliated trachea. These are very descriptively called "the band of hair-cilia".

The connective tissue between (m.t.) of the thyroid, spoken of above, and the outer covering of the gland, is seen, in Fig. 17, to consist of a thin mesh-work, around the gland, and of loose connective tissue, containing lamellia (m.l.). It also forms a thin membrane covering the surface of the large portion of the Rhabdial wall. Between the thyroid (Spritzlochernest) (spr.), the brain, and the mouth, enclosed space (l.v.), described as "lateral invagination", is more or less completely filled with connective tissue, containing fat cells, and also with blood vessels. This connective tissue also fills the spaces between the floor of the mouth and the thyroid. Numerous small blood vessels are found situated in it, both in that which fills the lateral invagination and in that which lies between the gland and the pharynx. This tissue is represented only in

to which necessitates the very deep ciliated groove shown in Fig. 14 and the right margin of the epiphysis (l.m.) is very large and the lumen of the groove is covered by a non-ciliate tissue membrane. There is no epithelial lining to the groove sections is represented by the right margin of the epiphysis. It is difficult to distinguish the two types of cells in the groove but they do lie closely together.

Fig. 15

The epiphysis of the right side of the body wall is shown in Fig. 15. The lumen of the epiphysis is large and contains a duct, a median ciliated chamber (m.c.) and a group of columnar cells, called the "Decklamelle". The epiphysis is broken off from the body wall at the point indicated by the arrow. The long cells of the epiphysis are seen to be ciliated.

The epiphysis of the left side of the body wall (Fig. 16) is now entirely free from the body wall and contains a large pocket (p.) which is bounded by a ciliated epithelium covering the duct, and ciliated epithelial cells covering the posterior end of the epiphysis. The epiphysis is shown at the point of breaking no other part of the body wall is visible. The epiphysis is for some reason inverted.

The epiphysis of the right side of the body wall (Fig. 17) is point free compared with the epiphysis of the left side. Starting from this point, the epiphysis (Fig. 17, p. 52) is directed upwards into the median ciliated chamber (m.c.) and covered by the cover cells (d.l.) (Decklamelle) of the two median pairs of cell-

in shape. In the first section, the dorsal edge of this ridge is the dorsal margin of the coil.

The epiphysis is situated on the right side of the coil and the duct lies on the left side. The epiphysis is a solid through the center of the coil. It is a small, rounded body from a corresponding point in the other sections (Fig. 5 b) except in

the first section where it is a long, narrow, slender end of the gland. The epiphysis (Fig. 5 a) is long and narrow. The epiphysis is situated on the right side of the coil part is made up of two sets of cells. The outer set of cells is lateral ciliated and the inner set is non-ciliated. The epiphysis is situated in the preceding section (Fig. 5 b) and above the gland in the next section (Fig. 5 c). In the next section (Fig. 5 d) it was situated on the right side of the coil. In this condition it is situated on the right side of the coil and above the gland. The epiphysis is situated on the right side of the coil and the duct is situated on the left side of the coil. The epiphysis is situated on the right side of the coil and the reticulated tissue is situated on the left side of the coil (Fig. 5 b).

The epiphysis and the duct (Fig. 5 a-d) all pass obliquely and oblique to the right side of the coil. The points indicated by the dots on the line do not coincide. The apparent compliancy of the epiphysis and duct will easily be plain by comparing them with the diagrammatic lateral view of the gland (Fig. 5 h). In all four sections, what we have called the lateral pairs of cell-groups (l.c.g.) remain the same and may be

recognized by their long, curved, lateral ciliated chambers (l.c.ch.).

In Fig. 8, the last whorl of collar-nerves are seen to be distributed in a definite way, which is followed in an anterior-posterior direction. In the middle dorsal position (m.c.d.), the nerve passes in a lateral-posterior direction, and gradually turns to the right, becoming almost straight as they pass dorsally. This change of direction is easily recognizable in the last whorl of the coil as shown in Fig. 9 k, where the collar-nerves are seen to pass in a lateral direction where the posterior-anterior gradient of the nerve is greatest. In the collar-trochae (m.c.g¹) there is a slight change of direction towards the anterior (m.c.g¹¹). The anterior gradient of the nerve is greatest, as this section, in contrast to the middle dorsal, is directed almost straight to the middle (m.c.m.). In addition to the anterior gradient, the general clarity of the nerve is also evident, as the nerve contains about three times more fibers than in the middle dorsal. The middle whorl of the coil, however, will be only approximately one-half as large as the last whorl in the sections of the coil, and the nerve will be cut in the sections.

The anterior gradient, however, is not as clear in the cell-surface as in the last whorl of the coil, m.c.g. in the anterior-posterior gradient of the nerve is evident. In the dorsal, anterior-posterior position, m.c.d., the length that is directed again towards the posterior end, and in m.c.g¹¹, in the last whorl of the coil which is directed towards the anterior

Fig. 7 shows two transverse sections of the four sections passed through the coil. The first section is at the point where the midrib is at its greatest height, and the second section is dorsalward to the first. The third section is at the point where the coiled end of the dissected whorl (Fig. 6) is at its greatest height, and the fourth section is at the point where the midrib is at its lowest point.

The first section shows that all cell-groups (layers) are present for a continuous whorl. The second section shows that the cell-groups are diminished in number, and they are in close contact.

The third section shows that the point about which the whorl is coiled is dorsalward and the midrib is at its greatest height. The cell-groups are in pairs of lateral groups, and the individual cells are markedly curved dorsad. The fourth section shows the coil has been completed, and the whorl is seen on each side of the midrib. The cell-groups are in pairs. Each pair consists of two cells, one of which is markedly curved dorsad, and the other is straight. Fig. 8 is a part of Fig. 7, showing the whorl above.

Fig. 9 shows a transverse section of the whorl at the point where the midrib is at its lowest point. The whorl is coiled, so that the midrib is ventral, and it is at the dorsal end of the whorl and sinks down again just behind this elevation. The groups of gland cells have diminished somewhat in cross section, but they

are not magnetized picked up at about the same posterior end.

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rudiment in the older, and it is well developed in the
older animals. As is seen in Fig. 19 a, the thyroid, which in
the younger larval stages was enormously large, proportionally,

is a small oval or bell-shaped line with columns of cuboidal epithelial cells (Fig. 121). The gills are composed of connective tissue and all the muscle fibers run obliquely from the median ventral side of the body to the gills. They are situated on either side, the right side being the larger. There are four to six gills.

The gills are situated on the right side of the body. The right side of the body is the larger. There are four to six gills. The gills are situated on the right side of the body. The right side of the body is the larger. There are four to six gills.

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(Figs. 6 a and b). Each half of the gland is a thin walled oval-shaped cavity. In one half of the gland, a sparse solution, in the sense of being less dense than the walls, one of a short columnar epithelial cell is found. It appears irregularly rounded, and it is this cell which projects into the cavity of the gland.

The other half of the gland is filled with a soft, loose, white, block of diffuse connective tissue, which extends forward, gradually becoming more dense, and more solid, but never reaching the consistency of a glandular wall. It contains a small papilla. This is the second type of the gland. The posterior end of the first type of gland is attached to the wall, and by a distance of about 2 mm. from the anterior end of the second type of gland.

Figure 7 shows a transverse section through the ventral part of the second type of gland. The large basilar nuclei (a.) are situated in the body between the body wall (b.) and the outer capsule (c.) of the gland. Embedded in the capsule are the two small glands (d.) whose walls are composed of the same material as the body wall. It has been mentioned,

that the basal nuclei of the second type of gland are absent under greater magnification. The body of the gland (b.) is shown, the section passing through the right side of the epidermis of the tract (d.) into the gland. This figure shows that the cells in the wall of the gland are formed by invaginations, of irregular form and at

the 2nd larva, the 2nd instar, some
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Fig. 1. Diagram of Lure of *Thomomys*. *GRANITI*.
 2nd. secondary group of gland p.h.l. posterior horizontal
 cells lamella

2. *Other Species.*

• [View Details](#) • [View Details](#) • [View Details](#) • [View Details](#) • [View Details](#)

Pl. 10. (See Fig. 10.)

Fig. 10. Lateral view of the head of a 13-day-old larva, showing the position of the thyroid gland, postero-laterally, and the invagination of the epidermis. The figure shows the head of a 13-day-old larva, viewed laterally. The thyroid gland is located postero-laterally, just below the epidermis. The epidermis is shown invaginating into the body wall. The brain is visible at the anterior end. The mouth is located at the anterior end. The gut is visible, showing the position of the thyroid gland, postero-laterally, and the invagination of the epidermis.

Fig. 11. Lateral view of the head of a 13-day-old larva, showing the relative size of the thyroid gland, and its position

and two lateral parts, so that it will no longer a complete epithelial layer, it will be called a ridge on its dorsal edge.

Fig. 6c. Ovary.

Fig. 6c. A median section through the middle of the ovary, posterior to the oviduct. The epithelial groove is still present, but the epithelial ridge has disappeared. (Mag. 90 diam.)

Fig. 6d. A median section through the middle of the ovary, anterior to Fig. 6c. A median section through the middle of the ovary, anterior to Fig. 6c, shows the now well developed epithelial ridge. Shows the now well developed epithelial ridge on the top of the gland, and the epithelial groove on the bottom. (Mag. 90 diam.)

Fig. 6e. Ovary.

Fig. 6e. A median section through the extreme posterior part of the ovary, anterior to Fig. 6d.

Fig. 6e. A median section through the extreme posterior part of the ovary, anterior to Fig. 6d. Shows the thyroid, the relative increase in size of the epithelial ridge, the relative decrease in size of the epithelial groove. (Mag. 90 diam.)

Fig. 6f. A median section through the anterior end of the ovary, anterior to Fig. 6e. All three groups of oviductal glands are now well developed and have increased greatly in size. The epithelial ridge on the top of the gland were magnified and the epithelial groove on the bottom. The epithelial ridge were magnified and the epithelial groove on the bottom. The epithelial ridge on the top of the gland was magnified.

Fig. 6g. Transverse median section posterior to Fig. 6e and just anterior to the opening of the duct. Corresponds to Fig. 6f of the preceding stage. (Mag. 90 diam.)

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Note: While compiling our first full investigation, I collected together all the literature on the subject until I obtained, I think, a nearly complete bibliography of the Cyclostomes. This bibliography will probably appear shortly.

Mr.,

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Polkstone, May 3, 1899.

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