VII.—On Some Points in the Early Development of Motor Nerve Trunks and Myotomes in *Lepidosiren paradoxa* (Fitz.). By J. Graham Kerr, Regius Professor of Zoology in the University of Glasgow. (With Six Plates.)

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INTRODUCTORY.

My main purpose in the following short paper is to publish figures illustrating some of the more important facts of the early development of myotomes and motor nerves in *Lepidosiren*. The bearing of some of the observations of nerve development upon current theories renders it particularly desirable that they should be illustrated by untouched photographs of the sections. A few photographs illustrating the more important stages* in the development of the motor nerve trunks are given on Plate I. For the preparation of the photographs here published, as well as several others, I am indebted to the skill of my friend Dr T. H. BRYCE, and of Mr FINGLAND, our University photographer.

DEVELOPMENT OF THE MOTOR TRUNKS OF THE SPINAL NERVES.

In describing the observed phenomena it will be convenient to begin with a late stage in development and work backwards to the earlier stages, and so pass from the better known and more familiar to the less known and less familiar.

Stage 34.—Fig. 1 illustrates a considerable length of motor nerve from stage 34.† Here the nerve (*n.t.*) consists of a cylindrical mass of nerve fibres about 13μ in diameter. On the surface of this the nuclei of the protoplasmic sheath are conspicuous. The greater part of the sheath itself is so thin as to be invisible even under the 3 mm. immersion objective, except in the neighbourhood of each nucleus, where it swells out to form a thick mass containing the nucleus.

Stage 31.—At this stage the nerve rudiment on superficial examination presents the appearance simply of a chain of nuclei placed end to end in a strand of protoplasm.

* By stage *n* I mean the stage represented by fig. *n* in my paper on the external features during development, *Phil. Trans. Roy. Soc. B.*, vol. cxcii. p. 299.

† Cf. RAFFAELE'S fig. in *Anat. Anz.*, 1900, p. 340 (Per la genesi dei nervi da catene cellulari). Cf. also KÖLLIKER'S remarks on this, *op. cit.*, p. 511.

Appearances, in fact, support the *Kettentheorie*—suggesting a chain of “cells” placed end to end. More careful examination shows the presence within the protoplasmic strand of a cord, faintly fibrillated longitudinally, and differentiated from the simple protoplasm by its affinity for eosin. The nerve runs downwards along the inner face of the myotome, and it is difficult to make out with certainty its connections with the cells of the myotome.

Stage 29.—At this stage (figs. 2 and 7) the conducting part of the nerve (*n.t.*) is in a similar condition to that described for stage 30—a distinctly fibrillated band—usually about 2.5 to 3μ in thickness close to its root—which stains deeply with eosin. It slopes outwards and downwards from the ventrolateral angle of the spinal cord to the inner surface of the myotome, along which it proceeds in a ventral direction. The protoplasmic sheath (*p.s.*), however, is now far more conspicuous than in later stages. It is a great, irregularly thickened mass of granular protoplasm, sharply marked off from the true nerve by its being stained more greyish in colour in hæmatoxylin and eosin preparations, in sharp contrast to the deep red of the nerve trunk.

Scattered through the protoplasm of the sheath are large nuclei rich in chromatin, yolk granules, and here and there vacuoles.

Stage 27.—At this stage (figs. 3 and 8) the most conspicuous difference from stage 29 is that the nerve trunk (*n.t.*) is now naked for the greater part of its length. At its outer end it spreads out into a number of strands arranged in a conical fashion. In the case of the strands near the axis of the cone—*i.e.* in the case of the strands which pursue a direct course towards the inner surface of the myotome—it may be clearly seen under a high power of the microscope that each strand passes perfectly continuously and by insensible gradations into the granular protoplasm, which forms a tail-like process of a myoepithelial cell of the myotome. In the case of many of the motor trunks at this stage there is to be seen a mass of mesenchymatous protoplasm (*p.s.*) richly laden with yolk, and containing numerous nuclei, concentrated in the neighbourhood of the nerve towards its outer end. This is the rudiment of the mesenchymatous sheath which in stage 29 we saw had spread out over the surface of the nerve. The nerve trunk itself is about the same thickness as in stage 29, though I find considerable variation in this respect.

Stage 25 (figs. 4 and 9).—A little behind the middle of the body at this stage the myotome is seen to be just commencing its recession from the spinal cord, mesenchyme (*me.*) cells* richly laden with yolk having begun to migrate in between the two structures. The nerve rudiment (*n.t.*) in the section figured is about 7μ thick. It is distinctly fibrillated, and at its lower end expands into a cone as in stage 27—the base of the cone, however, here being less expanded. Traces of longitudinal fibres are already visible on the ventrolateral surface of the spinal cord.

* Here as elsewhere I use the word “cell” merely as a substitute for the more cumbrous expression “nucleated mass of protoplasm” without in the least implying that it is separate from its neighbours. As a matter of fact the “cells” of the mesenchyme are merely the enlarged and nucleated nodes of an irregular continuous protoplasmic spongework such as SEDGWICK describes in Selachians.

Stage 24.—Transverse sections about the middle of the body at this stage (figs. 5 and 6) show the myotome still in contact with the wall of the neural canal, mesenchyme either not having intruded itself between the two at all, or only having done so to a very slight extent as yet except in the anterior part of the body. In embryos which have been excised while alive in normal salt solution, spread out in one plane like that figured to illustrate this stage in my account of the external features of development,* and fixed in this position, the myotomes are pulled slightly away from the neural tube. It is seen in transverse sections of such embryos that the rudiments of the motor nerve trunks already exist as soft thin bridges (*n.t.*) metamerically arranged and connecting spinal cord rudiment and myotome as shown in figs. 5 and 6.

The nerve rudiments at this early stage are formed of granular protoplasm either without yolk or containing only very minute granules, without obvious fibrillar structure when stained by the ordinary methods. The rudiment is quite naked, the richly yolked mesenchymatous sheath of later stages being conspicuous by its absence. Nor are there any nuclei in contact with the nerve rudiment. There can happily be no doubt about this in *Lepidosiren*, where the nerve rudiment in this early condition is of relatively small size compared with the dimensions of a single nucleus!

The nerve rudiment—composed as it is of soft protoplasm—is at first extremely fragile, gradually becoming tougher as development proceeds. Consequently in a straightened out embryo of this period we find the more posterior nerve rudiments—*i.e.* those in an earlier stage of development—show a greater and greater tendency to be torn away from the myotome in prepared sections. A nerve rudiment which has become torn away from the myotome is shown in fig. 10, which brings out a point more difficult to observe in the uninjured condition, that the protoplasmic mass forming the nerve rudiment spreads out over the inner face of the myotome. How far this expansion extends, whether—as is probable—it really covers the whole face of the myotome, is a point almost impossible to decide definitely by actual observation. Similarly I am deterred by the unreliability of observations made on a spinal cord so laden with yolk in its early stages from saying anything as to the connections of nerve rudiments with neuroblasts or other cellular elements in the substance of the spinal cord.

At this stage the spinal cord is without any obvious mantle of fibres.

The motor nerve trunk has thus been traced back to a period in which it is represented by a bridge of soft granular protoplasm connecting spinal cord and myotome at a stage when these structures are in close apposition. As the myotome becomes pushed outwards by the development of mesenchyme, it remains connected with the spinal cord by the ever-lengthening strand of nerve. As the nerve develops it soon loses its simple granular protoplasmic character and assumes a fibrillated appearance. Richly yolked masses of mesenchymatous protoplasm become aggregated round the nerve, which till now has been quite naked. At first this protoplasm forms an irregular mass towards the outer end of the nerve trunk, but it soon spreads along it and forms a definite sheath.

* *Phil. Trans. B.*, vol. cxcii., pl. 10, fig. 24.

This is at first very thick and conspicuous, but it gradually thins out, its yolk is consumed, and eventually the only parts remaining conspicuously visible are the nuclei dotted along the surface of the nerve trunk.

Into the subsequent history of the motor nerve—which is of minor morphological interest—I do not propose at this time to enter in detail.

The protoplasmic sheath grows into the nerve trunk, dividing it up into separate bundles of fibrils. The nerve trunk, as has been shown, spreads out at an early stage in conical fashion over the inner face of the myotome. As the myotome grows in surface this cone becomes broken up into distinct strands which become more and more divergent.

As the adult condition is reached the part of the nerve trunk proximal to the point of divergence—*i.e.* to the apex of the cone—increases relatively little in length. The distal portion, on the other hand, with its individual branches, increases enormously in length and the branches become more and more changed in direction as the muscles to which they are attached become pushed about by differential growth.

DEVELOPMENT OF THE MYOMERES.

The general features in the development of a typical myomere as seen in transverse sections are shown in text-figures A to H,* and in detail in Pl. III. and IV. figs. 11–14.

The protovertebra, at first (text-fig. A) a solid diverticulum of the enteric rudiment, develops a myocoelic cavity through the breaking down of its central cells about stage 21 (text-fig. B).

By stage 24 (text-fig. C) the myotome is beginning to show signs of a flattening from without inwards. The myocele is obliterated, and the cells of its mesial wall have become flattened in form. At their outer ends they interdigitate with the inner ends of the cells of the outer wall, so that the line separating the two walls in a transverse section is a zigzag one.

In stage 27 (text-fig. D, Pl. III. fig. 11) the inner wall cells have become more regular in shape; forming rectangular parallelepipeds flattened in an obliquely dorso-ventral direction, so that their larger faces slope inwards and downwards. Contractile fibres (fig. 11, *c.f.*) have now appeared in the body of these cells, running longitudinally and forming most frequently a layer close to each of the dorsal and ventral surfaces, the two layers becoming frequently continuous with one another externally, and sometimes internally. Very often, however, the arrangement of fibres at their first appearance does not show this regular arrangement. The contractile fibres appear to be rounded in section, and are easily distinguished by their highly refringent character, and by their peculiarly deep stain with Heidenhain's hæmatoxylin. The cells of the myotome are at this stage still laden with yolk, and this naturally is a difficulty in the way of observation.

The muscle fibrillæ are striped almost from the beginning. One can often see in

* These have been printed as separate Plates—V. and VI.

Heidenhain haematoxylin preparations that the young fibril appears to be made up of discrete particles arranged end to end.* But between these the protoplasmic matrix shows a more or less distinct fibrillar structure, the fibrils causing it having a longitudinal course and being continuous. These continuous fibrils appear to be an earlier stage of the contractile fibrils. The outer wall of the myotome in transverse section has the appearance of being composed of a single layer of large cubical epithelial cells. In horizontal sections the cell boundaries are less easy to make out, but when visible they show that the cells form a truly cubical epithelium. During mitosis these cells become more or less spherical.

Stage 31.—At this stage (text-fig. E, and figs. 12 and 12A) the outer portion of the muscle cell has increased in size, so that the outer limit of the contractile fibres is relatively much further removed from the outer end of the cell than it was before. In this outer end of the cell the cytoplasm assumes a clear transparent appearance, and in the preserved specimens large clear vacuoles are seen which possibly in the fresh condition contained glycogen. The inner part of the cell is now almost filled with contractile fibres, the protoplasm being reduced to the matrix between them. In this matrix yolk granules are still abundant, and it is noteworthy that the muscle cells are now becoming multinucleate, the original nucleus having divided repeatedly. The division is mitotic. As the divisions only take place at relatively long intervals, a little patience is required in hunting for the mitotic figures. The resting nuclei lie free in the protoplasm of the myoblast. It is interesting, however, that during the period of mitotic activity the nucleus becomes surrounded by a sharply delimited more or less spherical mass of protoplasm, simulating the appearance of a cell within the myoblast. So striking is this appearance (Pl. IV. fig. 14) that it suggested at first sight that more or fewer of the nuclei of the myoblast were really the nuclei of cells which had wandered into its substance from the mesenchyme without, just as such cells wander in later between the muscle fibres. On the whole, however, the balance of evidence is in favour of the cell-like structure round the nucleus being merely a temporary phenomenon due in some way to the influence of the mitotic activity of the nucleus on the surrounding cytoplasm—a phenomenon of the same nature as the rounding off into a spherical shape during mitosis of cells which in the resting condition are of more irregular outline.

The appearance of the myotome of this stage, as shown in horizontal sections, is indicated in Pl. IV. fig. 12A.

At about this period a striking change comes over the outer wall of the myotome. Numerous mitotic figures are observed in it. Its cells subdivide rapidly, so that the outer wall becomes several cells thick. The innermost of the cells so arising become squeezed in between the rounded ends of the primary muscle cells. At this stage it is often difficult to draw a line of demarcation between the outermost cells and those of the cutis which is now beginning to appear between myotome and skin. I am not, however, prepared to assert definitely that they actually give rise to cutis.

* Cf. GODLEWSKI, *Arch. Mikr. Anat.*, Bd. lx., 1902.

The outer wall cells now become converted into elongated irregularly cylindrical cells which stretch continuously from one muscle septum to the next. In the protoplasm of these there begin to appear about stage 31 + (Pl. IV. figs. 13 and 13A, and text-fig. F) contractile fibrils of a similar nature to those which have been long present in the inner wall cells. About stage 31 mesenchyme cells wander in between the myotomes. These give rise to the substance of the septum. Some also wander in between the muscle cells of the outer wall.

By stage 34 the layer of muscle cylinders arising from the outer wall much exceeds the inner wall in thickness. It is distinguished from the latter at the first glance, its muscle cells being slender cylinders instead of flattened parallelepipeds.

The general appearance in transverse section of a myotome of this stage will be gathered from text-fig. G. It will be seen that the lateral branch of the vagus nerve with its surrounding mesenchyme has formed an immovable obstacle, so that the myotome as it increases in thickness, and as it is pushed outwards by the increase of mesenchyme on its inner side, becomes gradually divided into two portions, a dorsal and a ventral, the two remaining for a time connected by a thin isthmus but being eventually completely separated. Along the mesial face of the myotome are seen the muscle cells of the inner wall, now reduced greatly in size in proportion to the whole thickness of the myotome.

The whole thickness of the myotome outside this consists of the derivatives of the outer wall. In its extreme outer portion it consists of cylindrical cells still in the condition described for stage 31, in which contractile fibres are just beginning to appear. From this in a mesial direction the muscle cells are seen to become of greater and greater diameter, and their contained contractile substance increases, especially in size, showing that the muscle cells are older as they are farther removed from the outer surface.

This, together with the fact that mitotic figures are numerous in the external layer, shows that this latter is the region in which growth in thickness of the myotome takes place.

The myoepithelial cells of the inner wall remain distinct up to about stage 35, though constantly becoming more and more insignificant as compared with the great mass of the myotome composed of muscle cylinders derived from the outer wall. About the stage mentioned, however, the myoepithelial cells begin to break down, portions becoming segmented off from their outer ends. These resemble the muscle cells of the outer layer in character, being long cylinders. This process goes on, and soon the once conspicuous myoepithelial cells have become entirely resolved into these cylindrical elements, and the myotome is composed of apparently similar elements throughout its thickness (text-fig. H).

GENERAL REMARKS.

1. *Motor Nerve Trunks.*

As is well known, there are three main views regarding the development of motor nerves in the vertebrata, which may be shortly stated as follows :—

(1) Each nerve fibre develops as an independent outgrowth from a ganglion cell which gradually grows out towards, and finally and secondarily becomes united to, its special muscle. The sheath of protoplasm surrounding the nerve is an accessory structure of independent origin developed from mesenchyme. This view is associated especially with the name of HIS, and is the view favoured by the majority of embryologists.

(2) The nerve trunk is multicellular in origin, consisting at first of a chain of cells, in the substance of which the nerve fibres are developed later, as fine fibres passing continuously from one cell body to another. The elements forming the original chain are most frequently looked on as ectodermal elements which have wandered out from the spinal cord rudiments. The protoplasmic sheath is derived from parts of the original cell chains which retain their protoplasmic character (BALFOUR, GOETTE, BEARD, DOHRN, v. WILHE, and others).

(3) The nerve trunk is not a secondarily formed bridge between spinal cord and motor end organ. It has existed from the first, and in subsequent development it merely undergoes elaboration from its at first simple protoplasmic beginning (v. BAER, HENSEN, SEDGWICK, FÜRBRINGER and others).

It is clear that the facts of development in *Lepidosiren*, at least in the motor nerves of that animal, give strong support to the last-mentioned view as regards the nerve trunk itself, and to the second view as regards the protoplasmic sheath. It has been shown that by the examination of earlier and earlier stages the motor trunk can be traced back, without, I think, any possibility of error, to a simple protoplasmic bridge which already connects the substance of the medullary tube with that of the myotome at a stage when they are still in contact.

As regards the origin of the protoplasmic sheath the evidence of *Lepidosiren* is equally emphatic. In its early stages the motor trunk is perfectly naked. About stage 27 masses of mesenchymatous protoplasm laden with yolk become applied to the nerve trunk, at first over only a small portion of its length, and these masses of protoplasm gradually spread over the whole trunk, remaining, however, for some time clearly distinguishable from the nerve trunk by their difference in staining reaction. As development goes on the yolk becomes used up, the protoplasm with its nuclei extends into the substance of the nerve trunk—doubtless to keep up the proper proportion between the bulk of the nerve trunk and its nutritive surface in contact with the sheath protoplasm. The protoplasm itself becomes less and less conspicuous, and eventually is only to be detected in the immediate vicinity of the nuclei.

Lepidosiren offers no evidence, so far, as to the ultimate origin of the nerve fibrils. They appear gradually in an at first simple protoplasmic matrix. They seem to form, as it were, a kind of picture in morphological symbols of already existent physiological activities. It would seem that the continued passage backwards and forwards between centre and end organ of a stream of nerve impulses gradually finds expression in the marking out of the original simple-looking granular protoplasm into definite fibrillar impulse tracks,* the undifferentiated protoplasm remaining as the perifibrillar substance. Such a view of the nature of the fibrils is supported by BETHE's remarkable observation† that in the chick embryo about the end of the sixth day a nerve trunk may lose its fibrillar character in the immediate neighbourhood of a mitotic figure, to reassume it on the completion of mitosis.

It is pretty clear that the great function of the sheath is to serve as a nutritive organ for the nerve trunk. We see how its protoplasm is at first laden with yolk which gradually becomes used up as the nerve trunk develops within it.

That the main function of nuclei, apart from reproduction, is to control cytoplasmic metabolism is well recognised. The nuclei of the sheath are able to exercise this control over the active metabolism of the developing nerve trunk which is without nuclei of its own. Connected with this relation of the sheath nuclei to the metabolism of the nerve trunk is no doubt the active multiplication of these nuclei observed in early stages of nerve regeneration.‡ In such regeneration it may well be that the protoplasmic matrix of the nerve simply repeats the process of its original development, increasing in size and then developing nerve fibrils within itself. If these fibrils represent merely the differentiated paths of nerve impulses passing through the substance of the protoplasm, it would of course happen naturally that the regenerated fibres would be formed in continuity with those of the undegenerated stumps. On this view the process which takes place when the peripheral part of a cut nerve degenerates and then regenerates is somewhat as follows:—The fibrils, no longer subject to the stimulus of passing nerve impulses, revert to their protoplasmic condition. The protoplasmic sheath becomes highly active.§ It increases in thickness: its nuclei divide actively. Its protoplasm digests the remains of the medullary sheath.|| It thus comes to contain stored-up food material as in its original embryonic heavily yolked condition. The protoplasmic matrix representing the degenerated axis cylinder lies imbedded within the sheath.¶ Controlled and supplied with nourishment by the activities of the surrounding sheath the protoplasm behaves just as it does in ontogenetic development: (1) it *grows*—probably slowly—and

* Were this the case, it might well be that the formation of fibrils might tend as a rule to spread from the end of the nerve from which came the most active and frequent nerve impulses.

† BETHE, *Allgemeine Anatomie und Physiologie des Nervensystems*, p. 244.

‡ BÜNGNER, *Ziegler's Beiträge z. Path. Anat.*, Bd. x., 1891.

§ WIETING, *op. cit.*, Bd. xxiii., 1898.

|| This view of nerve regeneration, which my ontogenetic work inclines me towards, appears to agree most closely with that enunciated by NEUMANN (*Arch. Path. Anat. u. Phys.*, Bd. clviii. p. 466).

¶ This protoplasmic strand within the protoplasmic sheath could only be demonstrated with extreme difficulty.

so gaps are bridged over; and (2) as soon as it has become continuous, nerve impulses beginning to play backwards and forwards in its substance cause again a differentiation into fibrils. As part of the impulse tracks persist as the stumps of the fibrils, the regenerate parts of the fibrils will naturally develop in exact continuity with these.

I have no intention of entering into a general discussion either as to the data in connection with the development of nerves in other Vertebrates, or as to the general conclusions which have been based on them. My purpose now is merely to emphasize the observations of the phenomena as they occur in *Lepidosiren*. I may, however, be allowed to point out that such observations as those of BETHE upon the Chick,* although apparently supporting the cell chain view, are in no way irreconcilable with the observations here chronicled. The soft protoplasmic bridges which form the first distinguishable rudiment of the motor nerve are difficult to observe in *Lepidosiren*, whose histological features are upon a relatively large and coarse scale; and how much more delicate and difficult to observe are the corresponding structures likely to be in the chick! It may well be that further research will demonstrate the existence of a delicate protoplasmic bridge about which are clustered the "nerve cells" (in APATHY's sense) observed by upholders of the cell chain theory.

DESCRIPTION OF PLATES.

GENERAL LIST OF ABBREVIATIONS.

<i>c.f.</i> Contractile fibrils.	<i>nu.</i> Nucleus.
<i>d.r.</i> Dorsal root.	<i>n.c.</i> Neural canal.
<i>g.</i> Glycogen-containing outer portion of myoblast.	<i>n.s.</i> Nuclei of protoplasmic sheath.
<i>i.w.</i> Inner wall of myotome.	<i>n.t.</i> Nerve trunk.
<i>l.vag.</i> Lateral branch of vagus.	<i>o.w.</i> Outer wall of myotome.
<i>me.</i> Mesenchyme.	<i>p.s.</i> Protoplasmic sheath of nerve trunk.
<i>m.n.r.</i> Motor nerve root.	<i>s.c.</i> Spinal cord.
<i>my.</i> Myotome.	<i>v.r.</i> Ventral root.
<i>n.</i> Notochord.	<i>y.</i> Yolk granules.

PLATE I.

[The figures on this plate are all from untouched negatives.†]

Fig. 1. Portion of spinal nerve of stage 34. (108·28 35.) *l.vag.*, *lateralis vagi*; *my.* myotome; *n.* notochord; *n.t.* nerve trunk; *n.s.* nuclei of protoplasmic sheath; *d.r.* dorsal root; *v.r.* ventral root.

Fig. 2. Portion of spinal nerve trunk of stage 29.* (93 C. 1435.) *my.* myotome; *n.* notochord; *n.t.* motor nerve trunk; *p.s.* protoplasmic sheath containing yolk granules (black), and large nuclei rich in chromatin.

* *Op. cit.*, p. 238.

† Much of the minute detail has unfortunately disappeared in the mechanical printing of these figures. I shall be glad therefore to show any specialists who are interested sun prints from the same negatives, in which the full detail is brought out.

Fig. 3. Part of transverse section at stage 27. (69 C. 1064.) Showing whole length of motor nerve trunk. *my.* myotome; *n.* notochord; *n.t.* motor nerve trunk; *p.s.* protoplasmic sheath now in form of a mass of richly yolked mesenchymatous protoplasm aggregated round the nerve trunk near its outer end. The greater part of the nerve trunk is still naked. At its outer end the nerve trunk passes out into conically arranged strands of protoplasm forming the inner ends of the muscle cells.

Fig. 4. Part of transverse section at stage 25. (79 A. 933.) *my.* myotome; *n.* notochord; *n.t.* motor nerve trunk already faintly fibrillated passing between spinal cord (*s.c.*) and myotome. The mesenchyme (*me.*) has not yet begun to concentrate round the nerve trunk.

Fig. 5. Part of transverse section at stage 24. (73 G. 986.) *my.* myotome; *n.* notochord; *n.t.* motor nerve trunk, at this time composed of granular protoplasm, and naked.

Fig. 6. Similar section to last, but taken from rather less advanced specimen. (Stage 24; 73 F. 688.) *my.* myotome; *n.t.* motor nerve trunk—a naked protoplasmic bridge connecting myotome and spinal cord (*s.c.*).

PLATE II.

[All figures are camera drawings of single sections. Figs. 7, 8 and 9 represent the same sections as are photographed in figs. 2, 3 and 4, with the additional detail visible under Zeiss' 3 mm. apochromatic homogeneous immersion objective.]

Fig. 7 (= fig. 2). The motor nerve trunk (*n.t.*) is seen within its thick protoplasmic sheath (*p.s.*).

Fig. 8 (= fig. 3). The motor trunk is now naked except for the large mass of yolk-laden mesenchymatous protoplasm (*p.s.*) which has concentrated round it towards its outer end. The continuity of nerve trunk with protoplasm of muscle cell is seen.

PLATE III.

Fig. 9 (= fig. 4). The nerve trunk is seen to be already fibrillar in structure. Mesenchyme (*me.*) has penetrated in between myotome and spinal cord, but has not yet begun to concentrate round the nerve trunk to form its sheath.

Fig. 10. Stage 24. The nerve has been torn away from the inner surface of the myotome so that its expanded outer end is seen.

Fig. 11. Part of transverse section, stage 30. (93 B. 2844.) The two walls of the myotome are seen—the outer one-layered, the inner composed of a layer of myoblasts in which are seen the first contractile fibrils (*c.f.*).

Fig. 12. Part of transverse section, stage 31. (103 D. 2463.) The outer wall of the myotome is beginning to show more than one layer of nuclei. In the myoblasts of the inner wall the contractile fibrils (*c.f.*) have greatly increased in number, most of the protoplasm of the inner half of the cell being converted into fibrils.

PLATE IV.

Fig. 12A. Part of longitudinal horizontal section at stage 31 (103 C. 822), showing a single myotome. *i.w.* inner wall cell; *c.f.* contractile fibrils; *g.* glycogen-containing outer part of cell; *nu.* nuclei of inner wall cell; *y.* yolk granules; *o.w.* outer wall of myotome, two of the nuclei undergoing mitosis; *me.* mesenchyme nuclei of septum between myotomes.

Fig. 13. Part of transverse section at stage 31+. (106 C. 1573.) The outer wall of the myotome is now several layers thick, and the cells of this wall have also developed contractile fibrils (*c.f.*).

Fig. 13A. Longitudinal horizontal section through a myotome of stage 31+. (106 A. 1811.) The nuclei of the inner wall myoblast are seen to have considerably increased in numbers. The contractile fibres of the outer wall (*c.f.*) are visible.

Fig. 14. A nucleus of one of the inner wall myoblasts during mitosis, showing the cell-like demarcation of the protoplasm immediately surrounding it.

FIG. 1.

FIG. 4.

FIG. 2.

FIG. 5.

KERR: EARLY DEVELOPMENT OF MOTOR NERVE TRUNKS
AND MYOTOMES IN LEPIDOSIREN PARADOXA. PLATE 2.

7.

Fig 7.

Fig 8.

8.

KERR: EARLY DEVELOPMENT OF MOTOR NERVE TRUNKS
AND MYOTOMES IN LEPIDOSIREN PARADOXA. PLATE 3.

KERR: EARLY DEVELOPMENT OF MOTOR NERVE TRUNKS
AND MYOTOMES IN LEPIDOSIREN PARADOXA. PLATE 4.

Figs. 12A, 13, 13A.

0 .01 .05 .1 mm.

Prof. J. GRAHAM KERR on "Some points in the Early Development of Motor Nerve Trunks and Myotomes in *Lepidosiren paradoxa*."—PLATE V.

DESCRIPTION OF TEXT FIGURES A-H.

Camera outlines of portions of transverse sections of the trunk region of young *Lepidosirens* at various stages, to show the topographical relations of the myotomes. Zeiss Obj. A, Oc. 2. *i.w.*, Myoblasts of inner wall of myotome; *l. vag.*, lateral branch of vagus.

FIG. A.—Stage 16.

FIG. B.—Stage 21.

FIG. C.—Stage 24.

FIG. D.—Stage 27.

FIG. E.—Stage 31.

FIG. F.—Stage 31+.

Prof. J. GRAHAM KERR on "Some points in the Early Development of Motor Nerve Trunks and Myotomes in *Lepidosiren paradoxa*."—PLATE VI.

FIG. G.—Stage 34.

FIG. H.—Stage 36+.