XXIV. *On the Corpuscles of the Blood.* *By* MARTIN BARRY, *M.D., F.R.S., F.R.S.E., &c.*

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THE principal facts recorded in the following memoir were incidentally observed during the researches which formed the subject of my last communication†.

(The measurements in this paper, as in former ones, are stated in fractions of a Paris line, and thus expressed (‴)).

Progressive Division of the Blood-disc into Globules.

1. My examinations of the internal generative organs in the Rabbit have generally been made at a period when these parts were found more or less highly vascular. In fluid collected at this period from the surface of the ovary, from the fimbriated portion of the Fallopian tube, or from the infundibulum, it is usual to find a large quantity of corpuscles of the blood, which are present also in other parts of the oviduct. It thus appears that blood-corpuscles become extravasated in these parts at the period in question.

2. Many of these corpuscles present an appearance (Plate XXIX. figs. 1. 2. α) resembling that generally exhibited by the corpuscles in blood obtained by venesection. But a very large number are in altered states, an idea of which may be obtained from such of the objects in fig. 2. as are not distinguished by a letter.

3. More particularly examined, and in considerable number, the objects in question are found to present every shade of transition between the unaltered blood-corpuscle Plate XXIX. fig. 1. α, and the mass of distinct globules, fig. 2. δ. This will be seen on inspecting successively α, β, γ, of fig. 1, and then the numerous unmarked objects in fig. 2; beginning in the latter figure with those most resembling γ of fig. 1‡.

4. Several of the appearances in the figures just referred to, will be recognized by those who have watched blood-corpuscles in the microscope, when undergoing the first alterations in their form. I find, however, that the presence of blood-corpuscles in these altered states, in the fluid above mentioned, is constant,—and this too when the parts are examined as early as a few minutes after the animal has been killed,—when therefore they are still warm. And what is more, in a portion of the fimbriated

† Researches in Embryology, Third Series: A Contribution to the Physiology of Cells. Philosophical Transactions, Part II., 1840, p. 529, that is, the present volume.

‡ It is perhaps deserving of notice, that a central pellucid cavity similar to that in other objects of this figure, was not observed in the centre of the mass of globules δ. Does it disappear as these globules form?

extremity of the Fallopian tube, removed immediately after death, I have seen blood-corpuscles in some of the altered states still circulating, or at least not quite at rest, within a blood-vessel. Hence it seems probable that the changes in question take place within the living body.

5. The altered blood-corpuscles just referred to, at first retain their flattened form, as will be seen on reference to fig. 2, which exhibits a few of them on their edges, or nearly so.—It may here be stated that my observations corroborate those of previous observers, that the blood-corpuscles in the Mammalia are biconcave; yet with Hodgkin and Lister†, I find them in Man to be rounded at the edges‡, and not cut off abruptly as they have been described§.

6. If the elliptic discs surrounding the germinal vesicle in a number of the figures of my "Third Series" be examined, they will be found in many respects to resemble the corpuscle of the blood, which—it will be recollected—in some of the Vertebrata has an elliptic form‖. Now all the cells referred to in that Series, were described as presenting in an incipient state essentially the same appearance as the objects surrounding the germinal vesicle. They were shown to exhibit a pellucid space surrounded by a finely granular substance.

7. I am reminded of this state by the appearance of the unaltered blood-disc. And certainly the division into globules to which we have now traced the blood-disc, is very far from lessening the resemblance.

8. A reference is here necessary to my "Third Series" on Embryology, *l. c.*, Plate XXIV. fig. 192. The object there seen consisted of a central pellucid space surrounded by one layer of what later stages showed to have been the foundations of cells. And if that object be compared with some of the altered blood-corpuscles in Plate XXIX. fig. 2. of the present paper, the appearance will be found to be essentially the same in both. Whether the globules into which the blood-disc resolves itself, are the foundations of new corpuscles of the blood, I do not know; but it is certainly not unimportant that there exists so perfect a resemblance, in appearance, between two objects, the nature of one of which has been ascertained¶.

† Translation of Dr. Edwards on the influence of physical agents on Life, Appendix, p. 431.

‡ I am indebted to the kindness of Professor Rudolph Wagner for some plates, intended to accompany the second part of his "Lehrbuch der Physiologie;" one of which, Tab. XIII., I observe contains figures of mammiferous blood-discs, rounded at the edges; as does also his work, "Beiträge zur vergleichenden Physiologie. Heft II. 1838."

§ Müller's Physiology, translated by Dr. Baly, Part I., 1837. p. 99. fig. 1.

‖ The blood-corpuscles of some of the Amphibia present a curious resemblance to many of the elliptic discs figured in my "Third Series" on Embryology, in the present volume.

¶ The condition of the blood-corpuscles above described (Plate XXIX. figs. 1 and 2.) is obviously that which was particularly observed, not only in very different mammals but also in one of the Amphibia, by Professor Owen (Med. Gaz. Nov. 13, 1839.). This eminent anatomist and physiologist has shown that the appearance in question presents itself in blood so recently drawn, that it cannot be considered as the effect of manipulation. It suggested to him "the idea that the blood-disc was undergoing a spontaneous sub-division into smaller vesicles; and although," he proceeds, "my observations are not at present sufficiently numerous to warrant the

9. The appearance of the globules in question suggests the idea that they may be identical with the so-called "lymph-granules," or blood-corpuscles of the "second form†."

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hypothesis that the development of smaller vesicles within itself is a normal property of the ordinary coloured vesicle or blood-disc, yet the obscurity which still hangs over the origin and reproduction of the blood-discs, and the unexpected constancy of the granulated form in a greater or less proportion of them, while recent, and floating in the serum, in the different species examined, makes me unwilling to suppress an idea, naturally arising out of such observations, and likely to be suggestive of examination of the same appearance by other microscopical observers." At the time of recording the above observations, I was not aware that such an idea had been published. I shall be glad if those observations are such as to confirm it. There is one fact mentioned by Owen which I think particularly deserving of attention here. In describing the blood of a cold-blooded animal—the *Monitor*—he remarks, "many of the discs had the marginal contour slightly crenate, *with lines converging* to the nucleus."—The appearance of the blood-disc when undergoing the changes which we have seen to terminate in a separation into globules, seems to have been noticed by several observers; among whom may be mentioned Hewson and Falconar, and more recently Hodgkin and Lister. It is not easy, indeed, to understand how the sharp-sighted Leeuwenhoek should have suspected the "globules" of the blood to be made of six lesser globules, unless he had seen some of the appearances in question. Some late remarks by Gulliver, to whom we are indebted for a vast number of observations on the size of the blood-discs in different animals, show that this gentleman had long been in the habit of observing these appearances, and that he deemed them of importance, He mentions having observed the "granulated particles in great numbers, both in their serum and in a dry state***in blood examined immediately after it was obtained from the veins of various animals, particularly young kittens. The nature of these particles," he continues, "is worthy of further and special inquiry. They are to be found plentifully during digestion; but, in their deep red colour and chemical properties, they differ remarkably from the granules observed in the chyle" (Lond. and Edinb. Phil. Mag. Jan. 1840.). The same author subsequently remarks, "The granulated particles are almost uniformly smaller than the common discs, and it is not improbable that some of the former may be produced by the irregular shrinking of the latter. In some instances I could not detect any of the granulated corpuscles in the blood immediately after it was taken from the animal, although they were to be seen abundantly after a few hours exposure in the serum to the atmosphere, the temperature ranging between 45° and 50°. In one observation some of the extremely minute spherules which are not uncommon in the blood, were observed to attach themselves to a few of the smaller discs, so as to produce the granulated appearance" (Lond. and Edinb. Phil. Mag. Feb. 1840, p. 107.). It would thus seem, however, that the idea of a division of the blood-disc had not occurred to the author now quoted.

† On the subject of these "lymph-granules" or corpuscles of the "second form," many valuable observations have been communicated by R. Wagner, from whose work—Beiträge zur vergleichenden Physiologie, Heft II. 1838,—I make the following extracts, in which will be found remarks that appear to me to be favorable to the suggestion above offered, on the possible identity of the globules into which the blood-corpuscle divides, with corpuscles of the "second form."

"In the blood of Birds, Amphibia, and Fishes, there is present in greater or less quantity a second form of corpuscles, which at first sight may be distinguished from the real blood-corpuscles, and to which the attention of physiologists was recently directed by Johann Müller. (Burdach's Physiologie, iv. S. 108.) [As Dr. Baly very properly remarks, Hewson probably saw the same objects, considering them the nuclei of the blood-discs. (Experimental Inquiries, &c. Part III. p. 133.) Hodgkin and Lister appear also to have seen them, (*l. c.*, p. 437.)] They have since been seen and closely investigated by many observers, and I long ago considered them at length. (Hecker's Literärische Annalen, 1834, Februarheft.) On the universal presence, the relative quantity, and the size of these granules, we have not yet any complete investigations.***In the arterial blood of a

10. The objects ε in Plate XXIX. fig. 2. were of a reddish colour, but larger than blood-corpuscles. They also presented distinctly a membrane at the surface, and contained globules or discs (each of which had its pellucid centre) surrounding a common pellucid space. One of the objects ε was elliptical, the others appeared more or less globular in form.

11. It is still a question with some, whether the blood-corpuscles in the embryo are formed out of granules of the yelk. My Second Series on Embryology† will I think have served to decide this question; for it was there shown that in the mammiferous ovum there exist no yelk-granules which can be so transformed; the ovum being filled with colourless transparent fluid.

Rapid and incessant Changes in the Form of altered Blood-corpuscles.

12. In Plate XXIX. figs. 3, 4, 5, are seen the momentary forms of objects which I observed in fluid collected on the fimbriated portion of the Fallopian tube, at the periods respectively of 5, 13, and $5\frac{1}{2}$ hours *post coitum*. These objects were altered corpuscles of the blood. Fig. 3. presents a gradual transition from the blood-corpuscles in fig. 1, to objects which in the absence of such connecting links would scarcely have been recognized as such.

13. These altered blood-corpuscles (figs. 3, 4, 5.) were in motion; rarely exhibiting a change of place, but presenting a rapid and incessant change of form. I have had many opportunities for observing these motions, which are often such as to be comparable to the writhings of an animal in pain. Sometimes one of the objects in question assumes in a twinkling an hour-glass shape, as if about to separate into two portions; but as quickly regains its previous form, or assumes a new figure. The condition, however, is by no means one of alternate rest and motion. The motion, as already said, is incessant, and so rapid that it is extremely difficult to catch and deli-

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young man of nineteen years, from whom blood was taken in Bronchitis, I found, besides the regular concave blood-corpuscles (averaging in diameter $\frac{1}{300}'''$), distinctly spherical finely granulated globules of $\frac{1}{300}'''$ to $\frac{1}{600}'''$, in appearance entirely corresponding to the second form of corpuscles, which are so easily demonstrable for instance in the blood of Frogs. Quite similar globules, though in more sparing quantity, I found in my own blood after venesection in consequence of inflammation.***I have since always found these corpuscles in drawn blood. ***They appear to stand in exact relation to the size of the blood-corpuscles of the animal.***They, however, vary much more in size than the [true] blood-corpuscles.***With respect to the form,***I hold them indeed to be globular, but perhaps globules pressed somewhat flat.***They are distinguishable from the other blood-corpuscles, also: 1. by being colourless; 2. by a certain lustre, and the property of strongly refracting light; 3. by their peculiarly granular appearance, so that they might be taken for aggregates of globules (nevertheless it appears to me that they are granular only at the surface)." R. Wagner then shows that the number of these corpuscles of the "second form" is greater in animals well-fed, and he mentions an instance in which they greatly increased after the blood had stood for two hours. R. Wagner, Beiträge zur vergl. Phys. II. pp. 19—48.

† Philosophical Transactions, 1839, Part II. p. 307.

neate any of the forms which arise. Sometimes the corpuscles suddenly become inverted; and I have observed certain of them (fig. 3. β.) which seemed to be horizontally revolving. The field of view in some instances is covered with these moving particles.

14. I have seen these motions of the altered blood-discs when the latter were covered,—in some instances with glass, in others with mica,—and also when uncovered; and I have observed them as late as two hours and a half after death, as in fig. 3†. They soon cease after removal of the fluid to the microscope. The cessation is, however, very gradual; rapid change of form passing into gentle undulations; and these being succeeded by an alternation of rest and motion.

15. In fig. 4. I have delineated the forms retained in one instance by four of the corpuscles in question after their motions had entirely ceased. The pellucid centres, such as those seen in the objects of this figure, are often not distinctly visible while the motions are proceeding. Sometimes, however, during rapid motion, I have observed appearances like those in fig. 5; the contained pellucid fluid being now central (α), then on one side (β), or divided into several parts (γ).

16. The addition of cold water does not immediately arrest the motions. I could not discern any in the remains of the corpuscles after dilute acetic acid had been added.

17. I have seen these motions of the altered blood-corpuscles, in fluid collected on the fimbriated portion of the Fallopian tube, in a Rabbit which had not had connexion with the male, but was killed during the rut.

18. They seem to be attended in some instances with a considerable increase in the size of the corpuscle (fig. 3. γ.)‡.

19. Should these facts be thought to confirm the opinion of HUNTER, that the Blood "has life within itself," or "acquires it in the act of forming organic bodies," because its corpuscles in certain altered states exhibit "vital action," still his assertion that "the red globules" are the least important part of the blood, will appear to have no just foundation§.

† The examinations were usually commenced a few minutes after the animal had been killed.

‡ Reference is made by R. WAGNER to a statement of CZERMAC with which I am unacquainted. "Vital motions," says WAGNER, "such as those which CZERMAC maintains that he has observed (for instance in Blood from the gills of the Proteus), I have never seen; and this assertion certainly rests on an illusion occasioned by the phenomenon which is produced by ciliary motion." WAGNER supposes the motions seen by CZERMAC to have been caused by portions of the gills, the cilia of which set the escaped corpuscles of the Blood in motion (Beiträge zur vergl. Phys. Heft II. pp. 17, 18.).

§ As stated in the London and Edinburgh Philosophical Magazine for August, 1840, p. 157, my later observations induce me to believe that the rapid and incessant changes in form of altered blood-corpuscles, described in pars 12 to 18. of this memoir, are caused by contiguous cilia; though I have not yet succeeded in demonstrating the latter. It is certainly a remarkable state of the blood-disc, however, which admits of such changes in its form.—November 1840.

The Chorion formed of Cells derived from Corpuscles of the Blood.

20. When the ovum is sought for in the Fallopian tube in the manner recommended in my "Second Series" on Embryology (*l. c.*, par. 313.), it is very common to find, in the mucus, patches of more or less altered blood-corpuscles. Plate XXIX. fig. 6. presents a minute portion of one of these patches, from the Fallopian tube of a Rabbit killed twelve hours *post coitum*. Many of the corpuscles (α), still flat, had undergone little change besides being pressed together into six-sided figures. Others (β) had become orange-shaped, highly refracted light, and presented in their interior a brilliant object, which in some instances (γ) was seen to be not central, but situated on one side. The diameter of the objects β was in general rather less than that of the unchanged corpuscles α. Whether this difference in diameter was referable to the change from a flattened to the more globular form, which would perhaps be sufficient to explain it†,—or whether an outer covering (present in α) had disappeared in β,—I do not know; but the occasional presence of extremely minute granules or globules around such objects (ε), leads me to think it very possible that the disappearance in question does take place. If the figure be closely examined, and more particularly on the left side, transition states will be observed between the unaltered corpuscles α, and the cell (for such it may now be termed) β. The figure presents several cells (δ) in which a further change had taken place. They had become elliptical.

21. In Plate XXIX. fig. 7. are seen blood-corpuscles, now cells, from the Fallopian tube of a Rabbit killed fourteen hours *post coitum*. Some of these (δ) were in a state resembling that of δ in fig. 6. Others had enlarged, and presented processes or arms. When viewed singly and highly magnified, such objects appear yellowish; an accumulation of them, seen by the unassisted eye, or with a low magnifying power, is blood-red.

22. I formerly showed‡ that during the passage of the ovum through the Fallopian tube, there rises from the thick transparent membrane (*f*) a thinner membrane. The latter was traced from stage to stage up to the period when villi form upon it, and thus ascertained to be the incipient chorion.

23. In a later paper§ I stated that the thin membrane in question (the incipient chorion) is formed of cells, and that these are not cells of the ovarian so-called "disc," but newly-arisen objects, the nature of which more particularly would be made known in a future paper.

24. If now my last memoir be referred to§, it will be found that the cells represented in Plate XXVIII. fig. 252 and 253. of that memoir, as forming the incipient chorion, have the same appearance as some of those in Plate XXIX. fig. 7. of the

† It did not escape the notice of Hewson, that the diameters of the red particles of human blood diminish from the particles becoming spherical, *l. c.*, pp. 18, 19.

‡ Researches in Embryology, Second Series, *l. c.*, pars. 172. 222. Plate VI. fig. 104. α and β.

§ Researches in Embryology, Third Series, *l. c.*, pars. 370 to 373.

present paper. And I confirm the statements made on that occasion; namely, that the cells send out processes or arms which interlace; that the contained pellucid object seems to enter into the processes or arms; that it is by a coalescence of the cells that the incipient chorion is formed; that the additions of cells appear to be continued up to the period when villi are produced; and that the villi themselves are probably formed out of the same kind of cells. It remains to add, that the cells in question, delineated in that paper, not merely have the same appearance, but are identical with those in Plate XXIX. fig. 7. of the present memoir: in other words, that the chorion is formed of cells which are altered corpuscles of the blood.

25. In Plate XXIX. fig. 8. are seen some of the very earliest traces of the formation of the chorion. The cells (g^1) of the tunica granulosa were described on a former occasion†, as becoming club-shaped and connected with the membrane *f* by their pointed extremities alone, after the fecundation of the ovum. Such is the form and position of the cells g^1 exhibited, for the most part in outline, in this figure. One purpose answered by the changes just mentioned as presented by the cells g^1, seems to be that blood-corpuscles (*cho.*) find their way between them, and have space for applying themselves to the membrane *f*, while this membrane continues to be protected by those cells‡. In fig. 8. several blood-corpuscles (*cho.*) are seen to have occupied the latter situation, where, in some instances, they appear to effect the alterations in their form above described§. Three of them, it will be observed, had become cells, and two were in the same stage as some of those in fig. 7, having begun to send out processes or arms‖.

26. For the announcement that the chorion is formed by corpuscles of the Blood, physiologists, I apprehend, are not prepared; it being the generally received opinion that the formation and the nourishment of organs are effected through its fluid part¶. But the next section records facts which, if established by future observation, involve more important consequences.

Muscular Fibre formed of Cells derived from Corpuscles of the Blood.

27. The latest researches, which have been published, on the mode of origin of muscle, are I believe those of VALENTIN and SCHWANN.

† "Third Series," *l. c.*, par. 345.

‡ Which also may afford fluid for the imbibition of the chorion. The protection above referred to is possibly essential during the transit of the ovum into the Fallopian tube.

§ In other instances those alterations occur before the blood-corpuscles take their places on the ovum.

‖ In Insects, a structure supposed to be analogous to the chorion of Mammalia, is often found to present itself in the ovary, and it "not rarely exhibits an elegant delineation consisting of flat coalesced cells." (R. WAGNER, A. Encycl. d. W. u. K. Erste Section, XXXII. "Ei," p. 4.)

¶ An eminent physiologist, however, has recently remarked: "What becomes of the blood-corpuscles,—whether they are transformed,—whether entirely or in part they are here and there deposited,—whether they dissolve, &c. has not been ascertained; we are reduced to mere hypotheses." (R. WAGNER, Beiträge zur vergl. Phys. H. II. S. 54.

28. "Muscular fibre," says VALENTIN, "arises***out of the jelly-like formative mass ***in the following manner: Long before separate muscular fibres are perceived, the globules of the primitive mass are seen arranged in longitudinal lines.***The granules ["globules"] now appear to approach one another, and in single places entirely—in others only on one side—to coalesce and unite into *one* transparent mass. By this means there arise threads, which in many places have a necklace-like appearance; in others are less distinctly notched, and often notched only on one side, the other side being straighter. Subsequently the thread loses every trace of granule ["globule"] or division, and becomes uniformly transparent, defined, and cylindrical.***Thus the muscular fibre continues when normal until about the period of the sixth month [of the fœtus], except that its substance becomes somewhat more opake and its cohesion closer. In the sixth month I have recently discerned on these fibres the first traces of transverse striæ, and hence (having now at command one of the best instruments of PLÖSSL) must retract the statement I formerly made, that these transverse striæ are entirely absent in the embryo. These transverse striæ however, during the whole of fœtal life are situated further apart, and discernible only with a clear light and high magnifying power.***From the period at which the muscular threads become transparent and uniform, there accumulate between them masses of round or roundish globules, which are somewhat larger than the blood-corpuscles—viz. 0·000407 Paris line. ***The muscular fibres are formed first, and subsequently their fibrillæ [contained within the fibres].***The younger the embryo is, the coarser are the elementary parts [of muscle].***We have above remarked that from the period at which the muscular fibre becomes uniform and transparent, globules accumulate in large number. Subsequently they diminish, and with the jelly-like mass—which holds them together—enter into the formation of the mucous tissue. This however unites—not the fibrillæ but—the fibres†."

29. More recently, and with reference to the doctrine of "cells," the same physiologist has communicated his views in the following words: "As soon as these [muscular fibres] appear in the fibrous form, there are seen in them round, very pale nuclei, which lie near together. From this it may be inferred, that here the cells arrange themselves likewise longitudinally, but coalesce immediately with one another without being drawn out into fibrillæ. This conjecture is confirmed by the fact that such an embryonic muscular fibre presents itself perfectly pectinate, as a confervafibril with a nucleus in each cell. This pectinate object, however, I have not hitherto so observed, as to have convinced myself of its complete natural conformity. There usually occur two circumstances which either call it forth or make it more distinct: 1. There follow the regular indentations of the muscular fibres, so that between two there always lies a regular nucleus. 2. On the transverse lines, which call forth the pectinate divisions, there lie very minute molecules with opake contours and a

† Entwickelungsgeschichte des Menschen mit vergleichender Rücksicht der Entwickelung der Säugethiere und Vögel, 1835, pp. 267. 268.

transparent centre, regularly and more or less transversely arranged in lines. The pellucid nucleus is in the interior of the hollow muscular fibre, and often projects in part or wholly when the latter is divided. Subsequently it becomes less and less easily recognizable. Within the muscular fibre there present themselves longitudinal fibrillæ, and soon afterwards transverse striæ. That in the interior of the muscular fibre the cavity remains, seems to be confirmed by my already communicated observation†, that the ends of divided living muscular fibres often become turned inside outwards.‡"

30. SCHWANN's views on the mode of origin of muscle have been published at length in his late work§. They have since appeared in the following condensed form: "According to the observations of VALENTIN, muscles arise out of globules, which apply themselves to one another in rows and then coalesce into a fibre, which represents the primitive muscular *fasciculus*. The fibre so arisen is a hollow cylinder, and in its cavity there lie near together the nuclei of cells (Plate XXX. fig. 18. α.). It is hence probable that the globules of which the fibre is composed were hollow, that is cells, and that the cell-nuclei in this cylinder are the nuclei belonging to those *primary* cells. The earlier process, which I have not observed, must thus have been the following: The (hollow) globules or *primary* cells applied themselves to one another in a row, or coalesced to form a cylinder; and then the partitions—by which the cylinder must have been divided—became absorbed. The nuclei are flat, they lie within the cylinder, not in its axis, but in its wall. This cylinder or *secondary* muscle-cell—rounded off and closed at one extremity—continues to grow like a simple cell; but only in its length, for in breadth it does not increase at all, but rather diminishes. The longitudinal growth, however, does not take place merely at the extremities, but in the whole extent of the cylinder; as is seen from the cell-nuclei—which at first lie near together—separating from one another, and even becoming much elongated themselves. Thus the muscle-fasciculus α (Plate XXX. fig. 18.) becomes converted into β. There now occurs the deposit of another substance upon the inner surface of the cylinder-wall,—that is [upon the inner surface of] the cell-membrane of the secondary muscle-cell,—whereby the wall becomes thickened and the cavity of the cylinder reduced in size (compare the fibre γ with β). That the thickening of the wall is not a thickening of the cell-membrane itself, as in cartilage, follows from the fact that the cell-nuclei do not become pushed towards the cavity of the cylinder, but remain lying at the outer part, in the situation they occupied before the secondary deposit began. This is shown in δ. The secondary deposit continues until the cylinder is entirely filled. The deposited substance becomes converted into very fine fibrillæ, which run longitudinally in the cylinder. These are the primitive muscle-*fibres*. They thus together form a bundle—the primitive muscular fasciculus—which

† HECKER's Neue Annalen, II. 71.

‡ VALENTIN, in R. WAGNER's Lehrbuch der Physiologie, I. pp. 137. 138.

§ Mikroskopische Untersuchungen, &c.

is inclosed by a peculiar structureless wall, the cell-membrane of the secondary muscle-cell†."

31. Such then are the latest published views on the mode of origin of muscle. I have now to record facts which in some of the main points seem to confirm these views, and to supply further information regarding early periods in the formation of muscular fibre. But should they be found sufficient for these purposes, they will solve a problem of no common interest, and this in a most unexpected manner.

32. The objects in Plate XXX. fig. 17. were found lying together in mucus pressed from the Fallopian tube of a Rabbit killed ten hours *post coitum*. These mixed objects viewed *singly* in the microscope, had the same colour as the corpuscles (red particles) of the Blood,—viz. a yellowish colour. *Accumulations* of such objects—which frequently present themselves—appear blood-red.

33. We have seen a gradual transition of blood-discs into cells for the formation of the chorion,—as in Plate XXIX. figs. 6, 7. If now the objects in Plate XXX. fig. 17. be closely examined and compared with one another, I think it will be difficult to resist the conviction that there is an equally gradual transition from unchanged blood-discs to cells entering into the formation of certain necklace-like fibres in the figure. The question then is, what are these fibres which blood-discs form?

34. In describing the mode of origin of muscle, VALENTIN remarks‡, that globules approach one another and coalesce to form threads, which in many places have a necklace-like appearance, but subsequently lose the traces of division and become cylinders. Could a more appropriate description have been given of the mode of origin of the fibres in my figures 14, 15, 16, 17§? SCHWANN conjectures‖ that the globules now referred to as having been observed by VALENTIN, are cells; that these coalesce to form a secondary cell, that is, the cylinder; and that the nuclei contained in the cylinder are the nuclei of the primary cells. He found the nuclei flat, and not in the axis of the cylinder but in its wall. My observations realise these conjectures of SCHWANN, and the figures just referred to attest the accuracy of his observations. I would here compare my fig. 15. with δ of fig. 18., borrowed for the sake of comparison from SCHWANN, and exhibiting a later stage; and if several objects in my

† SCHWANN, in R. WAGNER's Lehrbuch der Physiologie, I. pp. 140, 141. He adds: "A process entirely analogous to that which forms muscle is in operation, according to MEYEN, in the cells of the inner bark of trees. Here also there arise simple cells, which apply themselves to one another in a row, and through coalescence at the points of contact of the cell-membranes, and absorption of these coalesced partitions, become converted into a *secondary* cell, the wall of which thickens from a secondary deposit. The only question is, whether the substance which produces this thickening consists of longitudinal fibres" [fibrillæ], p. 141.

‡ See the quotations from this author, pars. 28. 29.

§ The objects in all these figures were pressed from the Fallopian tube, which it will be recollected becomes muscular at the period to which these observations have reference. Figs. 14 and 15. represent a minute portion only (merely the extremity), of a very considerable mass of fibres.

‖ See the quotations from this author, par. 30.

fig. 17. be compared with γ of fig. 18., taken from that author, a further correspondence will be observed. But it is not needful to refer to the observations of others, since the objects figured by myself *were obviously muscular fibres* (the future fasciculi) in the earliest stages of formation. There is therefore, it appears, a direct transition of blood-discs into the elementary parts of muscle.

35. My observations have not extended farther than the condition $\gamma\gamma$ of fig. 17.—for they were almost entirely incidental;—so that I am unable to state the mode of origin of the fibrillæ within the cylinder. But certain facts communicated in my Third Series of Researches in Embryology, may perhaps be applicable here.

36. It was there shown that a nucleus, after passing to the centre of a cell, resolves itself into the foundations of new cells. I would suggest that the nucleus may *thus* be the source of that "secondary deposit" described by VALENTIN and SCHWANN as thickening the membrane of the cylinder; and am the more disposed to think this possible, from the observations of SCHWANN on the frequent metamorphosis of cells into fibres. The existence of the longitudinal fibrillæ might perhaps be thus explained, for SCHWANN remarks, that these fibrillæ are formed out of the "secondary deposits."—This suggestion corresponds to one offered in my last memoir on the possible mode of origin of spiral fibres and other secondary deposits in vegetable cells.

37. It is not needful, however, that the central portion of a nucleus should leave the membrane of its cell, before the resolution of the free portion of such nucleus; of which the germinal spot in its last stages affords a remarkable example†. I regard the pellucid objects in the cells Plate XXX. figs. 15. 17‡, as occupying the place of the pellucid centres of the blood-corpuscles.

38. In the cells fig. 16. no such pellucid objects were observed at the surface. But the cells presented a lighter central space, which I believe to have corresponded to the pellucid objects in question,—these having passed to that situation. And if the pellucid objects here seen are the seat of changes analogous to those presented by the mysterious centres of nuclei elsewhere§, it is not difficult to conceive the mode of origin of the "secondary deposits" above referred to‖. The object $\beta\beta$ in fig. 17. presented a state apparently rather more advanced than those in fig. 16. The cells, however, had not coalesced. In $\gamma\gamma$ of fig. 17. the coalescence had more or less completely taken place; and it is deserving of notice, that what in $\beta\beta$ appeared the separate pellucid objects in question, had in $\gamma\gamma$ also coalesced, or seemed about to coalesce, to constitute the medullary portion of the cylinder. From the state of the fibre $\gamma\gamma$, it appears also that secondary deposits are in progress before the cylinder is fully formed.

† "Third Series," *l. c.*, pars. 327, 328.

‡ And also those in Plate XXIX. fig. 7, &c.

§ "Third Series," *l. c.*, pars. 375 to 395.

‖ That the pellucid object in the altered blood-disc really undergoes these changes, is to be inferred from Plate XXX. fig. 20. (par. 44.)

39. The purpose answered by the pellucid objects retaining in some instances a peripheral locality (fig. 18. δ. from SCHWANN), is no doubt an important one; but on this subject I do not hazard a conjecture.

40. The blood-corpuscles when passing into cells for the formation of muscular fibre, *are darker in colour* than those destined to form the chorion. There seems to occur in them *an increase of red colouring matter* (par. 43.).

41. The masses of globules seen by VALENTIN (par. 28.) to accumulate between the muscular threads,—globules which were "round or roundish" and "somewhat larger than the blood-corpuscles,"—I would suggest may really have been blood-corpuscles, which had assumed a globular form, and increased in size in the manner above described. VALENTIN, however, states that the globules in question entered into the formation of the "uniting mucous tissue†."

42. In connexion with the fact now recorded, that muscular fibre is formed of corpuscles of the blood, an observation may be referred to which has been mentioned by several authors‡; namely, that of a disposition to run into combinations, and form objects compared by HEWSON to rolls of coin. I find it very usual for this appearance to arise in blood obtained by a puncture (as of the finger), and to which no addition has been made.—R. WAGNER mentions that in blood taken from the heart of some of the Invertebrata—*Unio* and *Anodonta*—when the coagulating fibrin makes its appearance, blood-corpuscles are seen—*often grouped necklace-like*—around it.

43. Others have supposed muscular fibre to be formed by the blood-discs; but I am not aware of any facts having been observed which warranted the supposition. It is remarkable that a conjecture on this subject in one of the papers of Sir EVERARD HOME§ should have approached so near the truth. His conjecture was, "That the globules may be the part of the blood, out of which the muscular fibres are principally formed‖." Between Sir E. HOME's *observations* and my own, however, it will be perceived that there are material differences. For instance, he remarks, "When the globules of the human blood lose the colouring matter, they continue floating in the serum, and are seen to have an attraction towards one another so as to coalesce, uniting themselves together¶." In the altered corpuscles—that is, cells—which I saw uniting to form muscular fibre, the colour—so far from having disappeared—seemed (as already mentioned) to have become more intense (par. 40.).

State of the Blood-corpuscles during Vital Turgescence of the Vessels.

44. The appearance presented by the capillaries in highly vascular conditions of the internal generative organs, is remarkable. An idea of it may be obtained from Plate XXX. fig. 20, taken from a portion of the inner surface of the infundibulum of the

† Entwickelungsgeschichte, &c., S. 269.

‡ HEWSON (*l. c.*, p. 28.), HODGKIN and LISTER (*l. c.*, p. 436.), R. WAGNER (*l. c.*, p. 6.).

§ The Croonian Lecture, Philosophical Transactions, 1818, p. 172.

‖ Ibid. pp. 174, 175.

¶ Ibid. p. 174.

Fallopian tube in a Rabbit killed $5\frac{1}{2}$ hours *post coitum*. The vessels were *filled* with blood-corpuscles apparently to the exclusion of surrounding fluid. The corpuscles, in depth of colour, cell-like form, and general appearance, resembled those above described as entering into the formation of muscular fibre; but in most of them the usual place of the contained pellucid object was occupied by a substance which was obscure and dark, though presenting in some of the corpuscles a pellucid central point. This, however—from observations on the varying state of the interior of nuclei, and the continual origin there of fresh objects, recorded in my "Third Series"—so far from constituting a difference, seems to furnish a confirmation of my views as to the nature of the pellucid objects in question (par. 38.).—The largest vessel in this figure measured in external diameter $\frac{1}{200}'''$. But I have seen a vessel so filled, of many times this size.

45. The description now given of fig. 20. is applicable to the states of capillaries constantly observed at the period in question. The figure shows, that the corpuscles, having assumed a more or less globular or elliptic form, so completely fill their vessels as to be compressed into polyhedral shapes, and even to produce inequalities in the calibre of their vessels. When examined immediately after death, the contents of such vessels have in some instances exhibited here and there a slight degree of motion.

46. The vessels constituting a network under the epithelium-cells which carry cilia, and present the frill-like appearance in the outline fig. 19†, are filled with corpuscles in the above altered states‡. In other parts (fig. 21.) vessels are found so filled, which do not exhibit the same immediate connexion with the cilia-bearing cells.

47. I have seen both in the Fallopian tube and on its fimbriated extremity, a curious network (fig. 22.), apparently formed by the coalescence of blood-corpuscles, which, like those entering into the formation of the chorion, seemed for this purpose to have sent out processes or arms. The finest ramifications in arborescent states of the capillaries like that in fig. 21, have sometimes appeared to pass into a network of this kind§.

48. The above-described condition of the blood-corpuscles during vital turgescence of the vessels, I think deserving of consideration, in connexion with many of the phenomena attending local accumulations of blood, both in health and in disease; and more especially with reference to increased pulsation, the exudation of colourless fluid, and the heat and redness of inflamed parts.

49. Incipient epithelium-cells often present appearances which almost suggest the idea that these too are changed corpuscles of the blood. Compare in Plate XXIX. figs. 10, 11 with fig. 12. It is at least difficult to draw a line by which the two can

† See the explanation of the Plates.

‡ It is a part of fig. 19. which is represented on a larger scale in fig. 20.

§ On one occasion I observed a vermicular motion in a minute portion of such a network.

be distinguished, either in colour, form, or general appearance. (The epithelium-cells in question are frequently observed to lie in the same direction, their long axes being parallel.)

50. But if the great mass of the soft parts, muscle, is formed of corpuscles of the blood, how many tissues are there which they may not form?†

51. We are indebted to SCHWANN for the very important discovery, that "for all the elementary parts of organisms there is a common principle of development;" the elementary parts of tissues having, as he has shown, a like origin in cells, however different the functions of those tissues. The facts made known in the present memoir, if established by future observation, will not only afford proofs of the justness of the views of SCHWANN, but they will farther show that objects having all the same colour, form, and general appearance, namely, the corpuscles of the blood, enter immediately into the formation of tissues which physiologically are extremely different. We have seen some of these corpuscles to arrange themselves into muscular fibre, and others to become metamorphosed into constituent parts of the chorion. It is not, however, more difficult to conceive objects so much alike undergoing transformations for purposes so different, than it is to admit a fact made known by two of my preceding memoirs‡; namely, that the nucleus of a cell having a central situation in the group which constitutes the germ, is developed into the whole embryo, while the nuclei of cells occupying less central situations in the group, form no more than a minute portion of a membrane§. It is known that in the bee-hive, a grub is taken for a special purpose, from among those born as workers, which it perfectly resembles until nourished with peculiar food, when its development takes a different course from that of every other individual in the hive.

† "The nerves," says SCHWANN, "appear to arise in the same manner as the muscles; namely, through coalescence of primary cells in contact with one another and in a line, by which there is formed a secondary cell. But the primary nerve-cells have not been with certainty observed, because—so long as they are primary cells—they are not to be distinguished from the neutral cells, out of which arises the whole organ.***The fibres [secondary cells] are pale, granulated, and***hollow. There now takes place, as in muscles, a secondary deposit upon the inner surface of the fibre-wall, that is, upon the inner surface of the membrane of the secondary nerve-cell.***On the appearance of this deposit the cell-nuclei are usually absorbed; yet single ones continue, and then lie externally between the [deposited] substance and the [secondary] cell-membrane,***as in muscles. The remaining cavity of the secondary cell appears to be occupied by a tolerably firm substance, the band discovered by REMAK." (SCHWANN in R. WAGNER's Lehrbuch der Physiologie, I. pp. 141, 142.) Should it be found that nerves too are formed of blood-corpuscles, this band of REMAK may perhaps be constituted by coalesced objects similar to those apparently uniting to form the central substance in the muscle-cylinder (par. 38.), and which appear to be the essential part of altered corpuscles of the blood.—"The external appearance of tendons in the embryo," says VALENTIN, "is reddish, and not unlike the pale muscle-structures." (Entwickelungsgeschichte, p. 270.)

‡ Researches in Embryology, Second and Third Series, *l. c.*

§ Which I provisionally called the amnion.

52. Explanation of the Plates.

PLATE XXIX.

Fig. 1. Blood-corpuscles in fluid collected on the fimbriated portion of the Fallopian tube in a Rabbit killed eleven hours *post coitum*. α. Usual state, or but little altered; β. incipient division into globules; γ. more advanced stage in this division (paragraphs 2. 3. 4.).

Fig. 2. Blood-corpuscles in fluid collected on the ovary in a Rabbit killed seven hours *post coitum*. α. Usual state, or but little changed. The corpuscles in this figure which are not distinguished by a letter, present various stages in the division into globules, incipient in β of the preceding figure. Among the corpuscles are some in which the pellucid central portion is bounded by a dark line. Several are represented as viewed more or less laterally. In δ, the division has proceeded so far as to present the appearance of distinct though still adherent globules (par. 2 to 5. 8.). ε. Objects found with the foregoing (see par. 10.).

Fig. 3. Blood-corpuscles in fluid collected on the fimbriated portion of the Fallopian tube in a Rabbit killed five hours *post coitum*. These corpuscles were in motion. Those at α resembled several in fig. 2. β Appeared to be horizontally revolving on its axis. The corpuscles on the right side of β seemed to consist of a central and a peripheral portion, more or less corresponding in appearance to those at α; but in most instances the peripheral portion was less distinctly separated into globules, and in all of them the form was undergoing rapid and incessant change. γ. The central pellucid fluid had separated into three portions, and the motions of the entire object were such as to suggest the idea of its being about to undergo a like separation. The motions of these corpuscles were observed two hours and a half after death (par. 12 to 19.).

Fig. 4. Blood-corpuscles in fluid collected on the fimbriated portion of the Fallopian tube in a Rabbit killed thirteen hours *post coitum*. These, when first observed, were rapidly and incessantly changing their form. When their motions ceased they retained the forms exhibited in the figure. Their pellucid centres were scarcely, if at all, seen while the motions continued. Sometimes they appeared almost to separate into two portions, and then recover their previous form. The motion ceased gradually, gentle undulations having been the last change observed (par. 12 to 19.).

Fig 5. Several of the appearances presented by a blood-corpuscle observed changing its form as above described. The pellucid fluid, sometimes central (α),

seemed at other times on one side (β), and at others as though divided into several parts (γ). Taken from fluid collected on the fimbriated portion of the Fallopian tube, in a Rabbit killed $5\frac{1}{2}$ hours *post coitum* (par. 12 to 17.).

Fig. 6. Blood-corpuscles from the Fallopian tube of a Rabbit killed twelve hours *post coitum*. Many of them (α) flat, and in a condition little changed; others (β) become orange-shaped cells, a portion of their interior pellucid. In some (γ) the pellucid portion was seen to be, not central but, on one side. Certain of them (δ) had become elliptical. Some (ε) presented very minute adherent granules or globules (pars. 20. 21. 33.).

Fig. 7. Blood-corpuscles—now true cells—from the Fallopian tube of a Rabbit killed fourteen hours *post coitum*. Some of them (δ) resembled δ in fig. 6. Others had considerably enlarged, and sent out processes or arms. Such as these enter into the formation of the chorion. When viewed singly, the objects in this figure—with the exception of the pellucid portion which each presents—appeared yellowish; an accumulation of such objects is blood-red (pars. 21. 24. 25. 33.).

Fig. 8. Outline of part of an ovum of twelve hours, and measuring $\frac{1}{14}'''$, from the Fallopian tube. The cells of the tunica granulosa (g^1)—also for the most part in outline—had become club-shaped, and were in contact with the membrane *f* by their pointed extremities alone. The object of this figure is to show some of the very earliest traces of the formation of the chorion. Blood-corpuscles (*cho.*), having found their way between the cells g^1, apply themselves to the membrane *f*, and undergo the changes elsewhere described. Three of these corpuscles had passed into the state of cells, the contained pellucid object being at the surface; and two of these cells had begun to send out processes or arms (par. 25.). *e*. Proper membrane of the substance surrounding the germinal vesicle. Between this membrane and the membrane *f* there was a space, filled with transparent fluid.

Fig. 9. Blood-corpuscles in fluid collected in the infundibulum of the Fallopian tube of a Rabbit killed in the state of heat.

Fig. 10. Altered and now spheroidal blood-corpuscles in fluid collected in the infundibulum of the Fallopian tube, in a Rabbit killed four hours *post coitum* (par. 49.).

Fig. 11. Altered blood-corpuscles in fluid collected on the fimbriated portion of the Fallopian tube, in a Rabbit killed in the state of heat (par. 49.).

Fig. 12. Epithelium-cells, found with the blood-corpuscles in the preceding figure, and having very much the appearance of being formed out of such corpuscles. Some of them were beginning to send out a process, and they were all lying in nearly the same direction (par. 49.).

Fig. 13. Another form of epithelium-cells—formed of blood-corpuscles (?)—found with those in the preceding figure. Colour yellowish, except the contained pellucid objects. Their long axes parallel.

PLATE XXX.

Fig. 14. Blood-corpuscles—now cells—arranging themselves to form muscle. Found with an ovum of ten hours, taken from the Fallopian tube (par. 34.).

Fig. 15. A portion of the same, more highly magnified. The pellucid objects contained in the blood-corpuscles (now cells) in many instances were seen to be situated—not in the centre but—on one side. When viewed singly, these objects appeared yellowish; in a mass, blood-red (pars. 34. 37.).

Fig. 16. Blood-corpuscles—now cells—arranging themselves to form muscle. Some of them remarkably elongated (pars. 34. 38.). Found in the Fallopian tube of a Rabbit killed eleven hours *post coitum*.

Fig. 17. Blood-corpuscles (α, γ, δ), and portions of muscle ($\beta\beta$, $\gamma\gamma$) formed of blood-corpuscles, found with the objects figs. 14 and 15. This figure presents several transition states between the unchanged blood-disc α, and the necklace-like arrangement of cells $\beta\beta$. In the latter, the contained pellucid object had a central situation, but the cells had scarcely coalesced. $\gamma\gamma$ Presents a more advanced state. Here the cells had more or less coalesced into a cylinder, and the contained pellucid objects together formed, or seemed about to form, the medullary portion of the cylinder. In this figure are also objects resembling fig. 15. (pars. 32 to 35. 37. 38.)

Fig. 18. From SCHWANN (in R. WAGNER's "Icones Physiologicæ," Tab. XII. fig. 4.). α to δ, "Different stages in the development of muscle" (pars. 30. 34. 39.).

Fig. 19. Outline of capillaries as seen in a portion of the infundibulum of the Fallopian tube, taken from its inner surface, in a Rabbit killed $5\frac{1}{2}$ hours *post coitum*. These vessels were filled with blood-corpuscles in the state represented in fig. 20. At the lower part of this figure (fig. 19.) are epithelium-cells carrying cilia. These epithelium-cells are arranged parallel to one another, and perpendicular to the general direction of the capillary vessels. The small extremity of the epithelium-cells is directed towards the capillaries. Whence their frill-like appearance (in the figure), and the great extent of their ciliary surface. External diameter of the largest vessel $\frac{1}{200}'''$. 100 *diam.* (par. 46.)

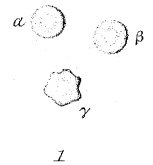
Fig. 20. A portion of the capillary vessels in the preceding figure, more highly magnified (300 *diameters*), to show the appearance of the blood-corpuscles with which they were filled. The blood-corpuscles presented in their

interior an object, which in most instances was more opake (redder) than the remainder of the corpuscle; but in some of the corpuscles the corresponding situation was occupied by a pellucid object (pars. 44. 45.).

Fig. 21. Outline of capillaries from the inner surface of the infundibulum of the same Rabbit, and filled with blood-corpuscles in the same condition as those in fig. 20; but not related to ciliated epithelium-cells in the manner exhibited in fig. 19. The external diameter of the largest vessel measured $\frac{1}{100}'''$. 100 *diam.* (pars. 46. 47.)

Fig. 22. Network formed apparently of altered blood-corpuscles, the arms of which (see Plate XXIX. fig. 7.) have coalesced. Found with the objects in Plate XXIX. figs. 11. 12. 13. (par. 47.).

Corpuscles of the Blood.



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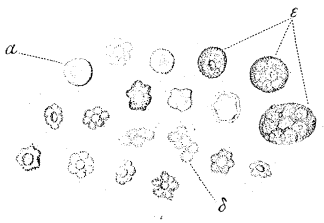

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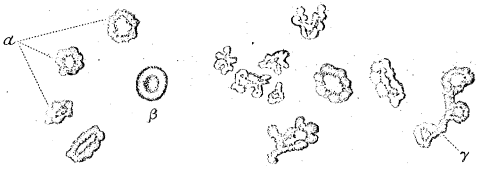

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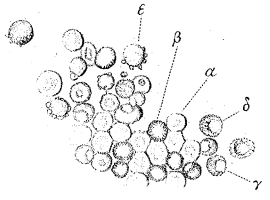

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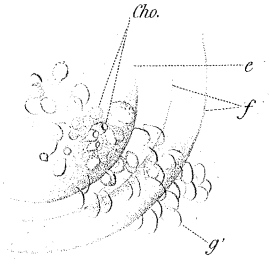

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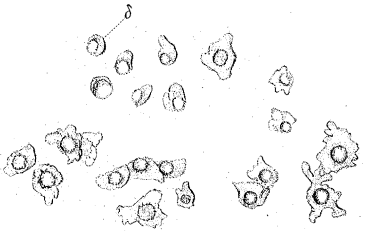

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All the Objects are from the Rabbit.—The diameters magnified vary from 200 to 400.

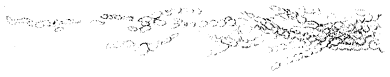
Fig.s 1 to 5. Blood-corpuscles, more or less altered. (ε Fig. 2 ?)

Fig.s 6 to 8. Blood-corpuscles, becoming Cells for the formation of the Chorion.

Fig.s 9 to 11. Altered Blood-corpuscles.

Fig.s 12, 13. Epithelium-cells.—(Altered Blood-corpuscles ?)

Corpuscles of the Blood.



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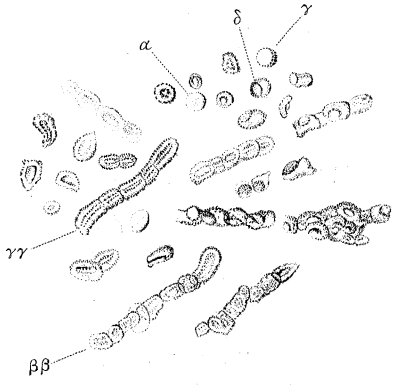

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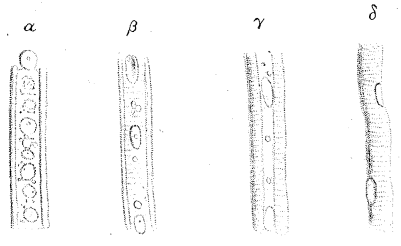

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(From Schwann)

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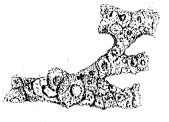

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(All the Figures are from the Rabbit, except fig. 18.)

Figs. 14 to 17. *Blood-corpuscles becoming Cells, which are forming Muscular Fasciculi.*

Fig. 18. *Muscular Fasciculi in a more advanced state. (from Schwann.)*

Figs. 19 to 21. *Capillaries filled with altered Corpuscles of the Blood.*

Fig. 22. *Network, formed of Blood-corpuscles ?*

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