XVI. *On the Corpuscles of the Blood.—Part II.* *By* Martin Barry, *M.D., F.R.SS. L. and E.*

Received January 13,—Read January 14, 1841.

Some time since, I laid before the Royal Society a few facts, which had incidentally fallen under my notice, connected with the red particles or corpuscles of the blood†. Those facts were of a character which led me to expect that the farther prosecution of the subject might be rewarded by the discovery of others; although, in a field of physiological research so often traversed from the days of Malpighi and Leeuwenhoek down to the present time, I could hardly expect to succeed in making any addition to the exact description given by some able writers of the present day, regarding the appearance of these corpuscles. But some ideas suggested during the examination of objects figured in the memoir just referred to, induced me to make the blood-corpuscles the subject of direct inquiry with reference to their mode of origin, and certain changes which they undergo.

It will be remarkable if the mammiferous ovum, which, because of its minuteness and the supposed difficulty of obtaining it, had been generally considered beyond the reach of satisfactory observation, should now become the means of studying, not merely other ova, but certain processes by which nourishment is communicated, and the growth of the body effected at all future periods of life. Such, however, I think will really be the case.

For the sake of avoiding a great deal of repetition, I shall at present confine myself very much to the general results; referring, for a particular description of the figures which accompany this memoir, to the minute explanation of them separately given (par. 87.). I may here state that, instead of perplexing the reader with measurements expressed in arithmetical figures, I have thought it preferable in all the drawings to represent the lines of the micrometer on which the objects lay; which lines are more particularly referred to at the foot of Plate XVII. I have taken the utmost care to represent faithfully the appearances presented by the objects examined; and an inspection of them will show that the undertaking occupied no small portion of time. Some of the differences between the drawings now presented and those of previous observers, are, I think, to be attributed to my having used a greater degree of care in the removal, by the usual means, of a portion of the colouring matter from the corpuscle, where required (par. 72.). In other instances, however,

† Philosophical Transactions, 1840, Part II. p. 595.

where none of the colouring matter was removed, I am unable to explain the cause of the differences in our observations.

53. A very superficial examination of the drawings, will suffice to discover the principal differences here referred to. It will be seen that the nucleus of the blood-corpuscle—usually considered, I believe, as a single object—is represented by me as composed, in some instances, of two, three, or even many parts; these having a constant and determinate form. The substance surrounding the nucleus is, I think, even by the latest observers, regarded simply as "the red colouring matter,"—forming the contents of what has been denominated the blood-cell. I find it not uncommon to be able to distinguish in this substance a great number of discs or cell-like objects; and, what is equally remarkable, to discern (in certain states of the corpuscle) an orifice in the delicate membrane by which this substance is surrounded. But it is not so much these facts to which I ask attention, as certain conclusions which they, with others, have enabled me to form.

54. In another memoir, also presented to the Royal Society†, I was under the necessity of expressing opinions no less differing from those of very distinguished physiologists, on a subject of the first importance; affecting, as it does, every tissue of which organized beings are composed—the physiology of "cells." SCHLEIDEN had stated, that, after giving origin to the membrane of its cell, the nucleus has performed its chief office; and that, when it does not continue at the surface of the cell, the nucleus is "cast off as a useless member, and absorbed‡." SCHWANN had said, that, with the exception of fat-globules having in some instances, in fat-cells, been seen to arise out of it, he had never observed anything whatever to be produced by the nucleus of the cell§. My observations, on the contrary, showed the nucleus to have a higher office to perform than that of giving origin simply to the membrane of a cell; that, instead of being "cast off as useless, and absorbed," the nucleus is the source of new substance,—a centre for the origin, not only of the transitory contents of its own cell ("Zelleninhalt" of German authors), but also of the two or three principal and last formed cells destined to succeed that cell; and, in fact, that by far the greater portion of the nucleus, instead of existing anterior to the formation of the cell, arises within its cavity.—A separation of the nucleus into two or three parts, where previously observed—namely, in the globule of pus and mucus—had been attributed by GUTERBOCK, HENLE, and others, to a chemical reagent used in the examination—acetic acid||. But, we saw that neither acetic acid nor any other foreign

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

‡ SCHLEIDEN, Beiträge zur Phytogenesis. MÜLLER's Archiv, 1838, Heft II. p. 146.

§ Mikroskopische Untersuchungen über die Uebereinstimmung in der Struktur und dem Wachsthum der Thiere und Pflanzen, 1838–9, p. 54.

|| HENLE, HUFELAND's Journal, Mai 1838, p. 62, pl. i. fig. 9–12.

substance is required to produce the separation in question; this separation being natural, apparently common to nuclei in general, and forming part of the process by which cells are reproduced. We found that young cells originate through division of the nucleus of the parent cell, instead of arising as a sort of "product of crystallization, in the fluid cytoblastema" of the parent cell, as since supposed by REICHERT†. The so-called nucleolus had been described as a distinct object, existing before the nucleus. But, we saw the nucleolus to be merely one of a series of appearances arising in succession, the one within the other, at a certain part of the periphery of the nucleus; and continuing to arise even after the formation of the cell.

55. My later investigations, I have now the satisfaction of stating, confirm the opinions just referred to, as well as others which I formerly expressed, but which are not recapitulated here; and the object of the present paper is to show, that they admit of being extended to the corpuscles of the blood‡.

56. The observations recorded in this memoir are based on an examination of the blood in all classes of vertebrated animals, in the embryo of Mammalia as well as that of Birds, and in some of the Invertebrata.

57. In certain states of the corpuscle of the blood its nucleus is single, like the central portion of the germinal spot in the germinal vesicle of the ovum. Such is the case at α in Plate XVIII. fig. 51. and at η in fig. 54. from Fishes, at α in figs. 49 and 50. from two of the Reptilia, at β in figs. 43 and 45. from the Bird, and in fig. 32. from the Mammal. In all the blood-corpuscles now referred to—which it will be seen are those of the four classes of vertebrated animals, including the two divisions of both Reptiles and Fishes,—the nucleus has a cavity or a depression; at the margin of which there occurs a high refraction of light. The appearance thus produced, seems to represent one of the states of the "nucleolus" of authors, in other cells.

58. The centre of the germinal spot undoubtedly communicates at a certain period with the exterior of the germinal vesicle; for strong presumptive evidence was brought forward, showing the introduction of some substance into the centre of this spot from the exterior of its vesicle. And, besides, I mentioned that in a certain

† Das Entwickelungsleben im Wirbelthier-reich, 1840, p. 2.

‡ They probably admit of being extended much farther. I cannot, indeed, but recognize in a paper by Professor VALENTIN, not merely dissent (in some instances at least) from the view above referred to,—that the nucleus is cast off, as "*useless*,"—but also facts which go to corroborate some of my own observations; however little the conclusions at which I arrived, resemble those of the author now mentioned. See MÜLLER's Archiv, 1840, Heft II. pp. 229, 230, and 235. The recent work of REICHERT also, before referred to, contains observations respecting which I would make the same remark. This author, however, adopts the mistaken view, that the nucleus of the cell is absorbed. For, considering the germinal vesicle as a nucleus, he *therefore* supposes it to disappear (*l. c.*, pp. 102, 103). The "finely granular" and "globular precipitate" of REICHERT, appearing around the nucleus, evidently arose from decomposition of the free portion of the nucleus (See my Third Series, *l. c.*, par. 391): to which cause seems referable the reduction he observed in the size of this object (*l. c.*, p. 91).

condition of the ovum, I had not been able to discern a continuation of the membrane of the germinal vesicle over the central portion of the spot. So likewise the corpuscle of the blood in certain states exhibits an orifice, by means of which there is a communication between the exterior of the corpuscle and the cavity in its nucleus.

59. The free portion of the germinal spot resolves itself into discoid objects—the foundations of cells; with which the germinal vesicle becomes filled. In like manner, the blood-corpuscle is seen filled with corpuscles of minuter size; presenting an appearance which I can attribute to no other than the same process. This is shown in the blood-corpuscle of the Fish at γ, fig. 52, at α and β, fig. 53, and at ε and ζ, fig. 54—in that of the Reptile, ε, figs. 49 and 50—in that of the Bird, fig. 36 β, fig. 41 β, fig. 43 β, γ, fig. 45, and fig. 47.

60. The foundation of the new being in the mammiferous ovum, arising in the centre of the altered germinal spot—which centre, from this and other facts, I denominated the point of fecundation—we saw to consist of two discs; each of these discs giving origin to a cell. So also, in more than half the numerous figures accompanying this memoir, we find the same appearances in blood-corpuscles, including those of Man. (In certain states, the nucleus of the blood-corpuscle is composed of three or more discs, instead of two. Figs. 33, 34 γ, 41 β, 43 δ, 45 θ, ι, 52 γ, δ, 53 α, 54 ζ. Compare with the nucleus of a yelk-globule from an immature ovum of the Tiger in my Second Series on the Embryo†).

61. The two cells in question, in the ovum, at a certain period are set free; each being destined to give origin to others. Such also is the case with the corpuscles of the blood. See figs. 29, 30, 39, 41 γ.

62. The foregoing analogies are not confined to vertebrated animals; for I have met with some of them, at least, in three classes of the Invertebrata. See figs. 57, 61 and 62.

63. Such facts as these appear to warrant the conclusion, that the corpuscles of the blood are generated by a process essentially the same as that described in one of my former memoirs, as giving origin to those cells which are the immediate successors of the germinal vesicle, or original parent cell.

64. If the blood-corpuscles of Man in fig. 23 be minutely examined in the order in which they are alphabetically lettered, and in connection with the description separately given (par. 87),—and if they be then compared with a succession of appearances delineated in my former paper on the Corpuscles of the Blood‡,—I think it will be obvious that those appearances arose from the blood-corpuscle resolving itself into minuter objects, by a continuation of the same process as that through which, as we have just seen, it is itself produced.

65. Eighty years have elapsed since the ingenious Father Di Torre, after presenting to the Royal Society some rude but powerful lenses of his own preparing, afforded

† Philosophical Transactions Part II. 1839, Plate V. fig. 87.

‡ *L. c.*, p. 595. Plate XXIX. fig. 2.

Sir F. H. E. STILES opportunities for viewing human blood by means of lenses of the same kind; when the latter communicated to the Society his observations, or rather the observations of DI TORRE, as confirmed by himself†. So little importance is attached, in the present day, to the observations of DI TORRE, that in historical accounts of the blood-corpuscles, I believe it is usual to pass them by, as not deserving of notice: probably from an idea that his optical instruments were too imperfect. But I shall not hesitate to here transcribe a passage from those observations of DI TORRE, although far from vouching for their entire accuracy.

66. "When," says the writer, "any of the globules [blood-corpuscles] happened to move with the serum in the most perfect focus,*** I could with great clearness distinguish the exterior and interior circumference of the ring, of which each globule [corpuscle] consisted; the interior one being bounded by a black line or shade next the perforation, exactly resembling that which bounded the exterior one,***. In such globules [corpuscles] I could easily observe the ring to be articulated, the transverse lines at the joints being very distinguishable. The figures of the articulations were various; in some they were roundish, so that the ring appeared like a bead necklace; in others, cylindrical, and of some length. The number of which the whole was composed, seemed uncertain, varying from two or three to six or seven; many of the rings were broke, either by some confinement of the talks [talc], or by beating against each other, which I saw them continually do; and by these accidents the joints of the rings were detached, and wandered about separately in great numbers; and indeed they appeared separable with as much ease as if they had been united by mere contact only. Some of the rings were broke into semicircles, others into greater or less portions, and others again divided into their constituent articulations, which in some places floated about single, and in others formed by their mutual attraction a lateral union, like the pipes of an organ. I must observe also, that these separated parts seemed to be hollow and transparent, and like inflated bladders, would easily yield, and change their figure, stretching or contracting themselves from round to oval and cylindrical, and *vice versâ*, as any lateral pressure in crouding [crowding] them along with the serum brought a constraint upon them. *** Although the articulation was not distinguishable in every globule, I think it was so in the greater part of them; and it is natural to imagine that the rest were articulated likewise, though they might not pass at the proper distance for its being distinguished‡."

67. Such were the observations placed on record by the Royal Society seventy-six years ago, which I had not read until fig. 23. of the present paper was nearly finished. As already stated, I do not believe they were accurate in all respects. But if the figure just mentioned be again referred to, it will be found that observations made by myself in 1840 and 1841, with an excellent instrument, while they very widely differ from those of late observers, confirm to a degree that is astonishing, some of the

† Philosophical Transactions, 1765, p. 252.

‡ *L. c.*, pp. 254, 255.

observations which had been made by Di Torre, with his rude and smoked lenses, in 1761. No one can feel more conscious than I do, how much we owe to Hewson for his researches on the corpuscles of the blood: but I think he erred in dismissing as valueless the remarks of the Italian observer.

68. I would add, once more referring to fig. 23, that the arrangement of the contents of the blood-corpuscle in the human subject, will be seen to coincide, in some instances, with its well-known usually biconcave form (pars. 73 to 76).

69. The form and internal state of the blood-corpuscle found in the adult of certain animals, very much resembles that existing only in the fœtal life of others. This will be obvious on an inspection of the drawings. That such resemblance is referable to uniformity in the mode of evolution, results from our whole experience on the reproduction of cells, as I explain it, and from facts above mentioned, showing that blood-corpuscles are generated by a like process; the difference between the condition of these objects in the embryo and in the adult of the same animal, being apparently referable to a difference in the degree of their development as cells.

70. An incidental observation may perhaps be mentioned here. The brain in the embryo of the Ox, at certain periods, appears to consist almost entirely of objects such as those in figs. 59 and 60; which, it will be seen, are composed of discs. Before the addition of acetic acid, such objects in many instances are surrounded by a halo, which seems to represent the membrane of a minute cell. If the objects now mentioned be compared with some of the nuclei of blood-corpuscles which I have figured, it will be found that there is a remarkable similarity between them.

71. On a review of the facts stated in the course of the present communication, the opinion I have been led to form, is that the mode of evolution of the minute mammiferous ovum is deserving of close attention in connection with some of the processes by which nourishment is communicated, and the growth of the body effected at all future periods of life.

Appendix.

The following additional remarks were kept out of the memoir itself, for the purpose of rendering it as simple and brief as possible.

72. The chemical reagent principally used in the investigations forming the subject of this paper, has been dilute acetic acid of the strength of distilled vinegar. I have found it an advantage to add this acid in a quantity so very small, as to be enabled to witness its gradual effect upon the contents of the blood-corpuscle. It has been by this means, in part, that I have discerned the interior of this object to be, to my astonishment, so different from that represented by previous observers.

73. Professor MÜLLER remarks, "It is quite impossible to imagine the cause of the different forms of the red particles in the different classes of vertebrated animals. There are no similar elementary forms in the whole body†."

74. It will be obvious that I cannot agree with the eminent physiologist now mentioned, in the latter part of the quotation; the main object of this memoir having been to show that the blood-corpuscles are generated by a process of the same kind as that which I have elsewhere described. But I wish to ask attention in this place to the former part of the passage just quoted from Professor MÜLLER,—as to the possibility of imagining the cause of the different forms of the red particles in the different classes of vertebrated animals; for, perhaps some of the accompanying delineations may assist us even here.

75. Dr. YOUNG denied the existence of a nucleus in the corpuscle of human blood: HEWSON believed it to be globular: MÜLLER remarks, "And as this nucleus [of the blood-corpuscle] has under the microscope exactly the same appearance in the red particles of Birds and Fishes as in those of Amphibia, it would be expected to exist in those of Mammalia also. And although, on account of the minuteness of these bodies in Mammalia, it is more difficult to demonstrate the nucleus in them, I have with an excellent (FRAUNHOFER) microscope really seen it, and distinctly. Even in the red particles of human blood, I have seen a minute, round, accurately defined nucleus, which had a more yellowish and shining aspect than the transparent part around it. The existence of the nucleus can also be demonstrated by the action of acetic acid, though much less distinctly than in the case of frog's blood‡."

76. To me the appearances presented by the nucleus of the corpuscle in human blood, after the addition of acetic acid, were such as those represented in fig. 23: some of which, I think, are really sufficient to explain its usually biconcave form, and the difference in this respect between the blood-corpuscle of the Mammal and that of other Vertebrata.

77. I am very much inclined to believe, that in the many instances in which authors on "cells" have described and figured more than one nucleolus in a nucleus, there has been either an incipient division of the nucleus into discs, or the nucleus has consisted of two or more discs: the nucleoli of those authors having been the minute and highly refracting cavities or depressions in the discs§. If this has really been the case, it affords additional evidence, I think, that reproduction of cells by the process I have described—namely, division of the nucleus of a parent cell—is universal; so numerous have been the instances in question. I may refer to the figures given

† Elements of Physiology, translated by Dr. WILLIAM BALY, p. 146.

‡ *L. c.*, pp. 100, 101.

§ The observer is very apt not to perceive that a nucleus is composed of more than one disc, because of the refraction of light being very small at the part where the discs lie one against the other.

by SCHWANN†, who examined nearly every animal tissue, and to those of SCHLEIDEN‡, whose observations have been so extended on the cells of plants. I think, indeed, that many of the figures of SCHWANN afford evidence of the division in question having taken place. It is to be recognized in his delineations of the cells of cartilage§, cellular tissue||, the middle coat of the aorta¶, muscle††, tendon‡‡, the feather§§, &c. The same remark is applicable to a figure given by REICHERT of ciliated epithelium-cells||||. Dr. HENLE found that in the layers of his "Pflasterepithelium" cells, the nucleus, very distinct in the lower cells, had almost disappeared in those situated at the upper part. From this observation, and from the presence of two nucleoli in some of the nuclei figured by this observer¶¶, as well as from the nucleus becoming "more granular†††," I think it extremely probable that these cells also (including those of the epidermis) are reproduced by the process just referred to—division of the nucleus; additions being no doubt continually made at the lower part of the layer, by which cells previously there are pushed further out. Dr. HENLE mentions that in the lowest of the cells of "Pflasterepithelium," the nucleus is "reddish yellow, and has a remote resemblance to blood-corpuscles‡‡‡." This is very interesting in connection with an observation recorded in my former paper on the Corpuscles of the Blood. I stated that epithelium-cells had often presented appearances which almost suggested the idea that these too were changed corpuscles of the blood: and that it was not easy to draw a line, by which the two could be distinguished, either in colour, form, or general appearance§§§. The cells here referred to were probably the "cylinder," or rather the subsequently "flimmerepithelium" cells of HENLE||||||.

78. I showed on a former occasion that the chorion arises by a coalescence of minute cells¶¶¶; and we have since seen the thickening of this membrane to be effected by the same means††††. The cell which (in the first of my communications to the Society) I called the ovisac, appears to arise in the same manner, as well as the membrane *e* of my papers on the Embryo, for it really does appear, as I formerly suggested‡‡‡‡, that the substance surrounding the germinal vesicle in the mammiferous ovum, usually called the yelk, may be termed a great "cytoblast."

† *L. c.* ‡ *L. c.* § *L. c.*, Tab. I. figs. 8, 9. Tab. III. fig. 1. || Ibid. Tab. III. figs. 6. 9.
¶ Ibid. Tab. III. fig. 12. †† Ibid. Tab. III. fig. 13. ‡‡ Ibid. Tab. III. fig. 11.
§§ Ibid. Tab. II. fig. 11 *a*. |||| *L. c.*, Tab. I. fig. 4. ¶¶ *L. c.*, Tab. I.
††† Ibid. p. 7. ‡‡‡ *L. c.*, p. 6. §§§ *L. c.*, par. 49. Plate XXIX. figs. 11, 12.

|||||| See my Researches in Embryology, Third Series, *l. c.*, Plate XXVIII. fig. 251, which presents apparently more advanced stages of the objects delineated in the figures referred to in the preceding note.

¶¶¶ Derived from corpuscles of the blood. Researches in Embryology, Third Series, *l. c.*, par. 369–373. On the Corpuscles of the Blood, *l. c.*, par. 20–26.

†††† Supplementary Note to a paper entitled "Researches in Embryology. Third Series: A Contribution to the Physiology of Cells," in the present volume, p. 193.

‡‡‡‡ Third Series, *l. c.*, par. 350. *Note.*

79. Now this mode of origin of cells of comparatively large size, may perhaps assist us in the consideration—how are the minuter ones produced? I formerly stated† that it was not easy to point out where the disc terminates, and the cell begins; and that I did not recollect to have observed any of the discoid objects in the transition state in question, in which there was not an appearance in the most superficial part denoting decomposition. I added, that so uniformly had this been met with that I was ready to suppose the formation of the cell-membrane to be connected with such decomposition, or perhaps dependent on it. From later observations, I am more and more disposed to think that this really is the case; and that exceedingly minute discs, into which the outer portion of a larger disc has been resolved, coalesce to form the membrane of the cell. Thus in fig. 54. the outer portion of discs such as those at α, seemed at β to have resolved itself into minuter discs, which at γ were more advanced, and at δ had coalesced to form the membrane of the corpuscle or blood-cell.

80. It will be seen from what I have in this memoir, and elsewhere, stated, that the disc ("nucleus" of authors) is the most primitive object we are acquainted with. It will also be perceived that the cavity or depression ("nucleolus") in the disc, is the situation of the future orifice, communicating with the exterior of the cell. The nucleus of the cell seems to be reproduced by the fissiparous mode.

81. The objects into which the nucleus of the mammiferous blood-corpuscle separates (fig. 23.), are no doubt the source from whence proceeds the substance for the origin and thickening of the chorion, and the formation of the muscular fibril‡.

82. The process by which the nucleus of the cell finally divides into several parts, seems to consist in the originally single and pellucid cavity or depression in the nucleus, gradually becoming finely granular (see the explanation of fig. 43.); and by degrees separating into several cavities. An idea of this change may perhaps be obtained from the condition of the nucleus in the blood-corpuscle ζ, fig. 45.

83. The nuclei which several observers have found lying among the fibres of various tissues, have been considered by them as the "remains of cells." This may have been the case; but so far from thinking, with those observers, that the nuclei in question were "destined to be absorbed," I am disposed to consider that they were the sources from which there would have arisen new cells. See, for instance, delineations by SCHWANN of nuclei lying among fibres from a feather (*l. c.*, Tab. II. fig. 13.). (And I may here take the opportunity of remarking, that I apprehend the fibres in

† Third Series. Additional observations, par. 439. *Note.*

‡ See my Third Series on the Embryo, *l. c.*, and also the figure accompanying a Supplementary Note to that Third Series, in the present volume, p. 193; as well as my first paper on the Corpuscles of the Blood, *l. c.*

the more advanced of the objects in this figure, to have arisen from the coalescence of discs such as those represented in the object presenting an earlier state: a view which SCHWANN does not appear to have taken.)

84. I have observed, here and there, in blood taken from the liver in the fœtus of the Ox, large cells such as those represented in outline in fig. 31. (See the explanation of the Plates.) The nuclei of these cells presented a very remarkable appearance. They were composed of transparent discs, having, as viewed in the microscope, that peculiar yellow colour, which seems to characterize the corpuscle of the blood; and which when these corpuscles are accumulated, presents to the naked eye the well-known red. These discs, perhaps in some instances about twelve in number in each nucleus, were elliptical, and exhibited a cavity or depression. They were distinctly unconnected, though in contact, with one another; and seemed on the point of being separated. The figure represents one cell from which they were escaping.

85. Future observation must determine what these discs really are, I venture to believe it very possible that they represent a state of the corpuscles of the blood.

86. On a former occasion†, I showed that the blood-corpuscles in the embryo are not formed, as supposed by some observers, out of granules of the yelk. The facts recorded in the foregoing memoir leave little doubt, I think, that these corpuscles,—not only in the embryo, but at all periods of life,—are descendants of the two cells constituting the foundation of the new being in the ovum. If so, it is not requisite to seek the origin of these corpuscles in the organized parenchymatous substance of the body, or in the globules of the chyle; "the only two sources," it has been said, in which it was possible for them to arise. Authors on "cells," regarding the liquor sanguinis as the "cytoblastema," appear inclined to consider the corpuscles of the blood as arising in it, independently of previously existing corpuscles.

87. EXPLANATION OF THE PLATES.

PLATE XVII.

Fig. 23. Man. Blood-corpuscles, after the addition of acetic acid. *α*. The nucleus consists of two adherent discs. *β*. The two discs have separated, and increased in size. *γ*. They exhibit symptoms of division. *δ*. The discs are four in number; but two of them remain attached. *ε*, *ε*. There exist three separate discs, with indications of a division of some of these discs. *ζ*. The number of discs visible is five. Three of the objects are in this state. *η*. The nucleus is indistinctly seen, from the surrounding discs and red colouring matter having been imperfectly dissolved.

† On the Corpuscles of the Blood, *l. c.*, par. 11.

Fig. 24. Ox (*Bos Taurus*, Linn.); embryo of $\frac{3}{4}$ths of an inch in length. Corpuscles of blood taken from the back part of the head. α. The nucleus consists in two instances of two, in another instance of three discs, which are in close approximation. β. The discs have separated, much increased in size, and assumed a cell-like appearance. γ. The corpuscle exhibits an orifice.

Fig. 25. Blood-corpuscles from the same embryo, after remaining twenty-four hours between two plates of glass. They had begun to collapse; a change which seems to commence by a falling in of that part of the membrane where the nucleus lies, and where an orifice in the membrane is in some states to be discerned.

Fig. 26. Blood-corpuscle from the liver of the same embryo. The nucleus seemed to consist of two portions.

Fig. 27. Blood-corpuscles from the liver of the same embryo, after the addition of acetic acid. The latter has made them globular. In all, the nucleus consists of two discs. In the lower one, large discs or incipient cells are represented surrounding the nucleus.

Fig. 28. Ox (*Bos Taurus*, Linn.); embryo of about one inch in length. Outline of corpuscles in blood taken from the back part of the head. These were not very flat, especially the smaller ones, which were much more numerous than the large. α, α. The corpuscle presents an orifice. β. A nucleus is visible, consisting of two closely adherent discs.

Fig. 29. Blood-corpuscles, chiefly in outline, from the same part of the same embryo, after the addition of acetic acid; which has rendered most of them spherical in form. After some time, they became shrivelled in appearance. α. Ruptured corpuscle. β. Corpuscle from which a globular object (presenting on one side the membrane of a minute cell?) is escaping. γ. Object nearly resembling a mature blood-corpuscle, surrounded at a little distance by a membrane. δ. A similar object on its edge, but without a surrounding membrane. It presents an orifice on one of its broad surfaces.

Fig. 30. Ox (*Bos Taurus*, Linn.); embryo of $1\frac{1}{4}$ inch in length. Outline of blood-corpuscles from the liver, after the addition of acetic acid. α. Corpuscle containing two globules, composed of discs. β. Corpuscle discharging a globule of the same kind; the membrane of a minute cell rising from this globule. γ. A similar compound globule, probably recently discharged from a corpuscle, and now eccentric in a minuter cell.

Fig. 31. Ox (*Bos Taurus*, Linn.); embryo of $1\frac{3}{4}$ inch in length. Outline of corpuscles in blood from the back part of the head, after the addition of a very minute quantity of acetic acid. In the larger ones, the nucleus

became well circumscribed through this addition. These corpuscles exhibited a pellucid orifice.

Fig. 32. Outline of a corpuscle from the same embryo; the nucleus consisting of a single disc.

Fig. 33. Sheep (*Ovis aries*, LINN.); embryo of $2\frac{1}{2}$ inches in length. Blood-corpuscles after the addition of acetic acid.

Fig. 34. Blood-corpuscles from the liver of the Ox-embryo from which figs. 31 and 32 were taken. Acetic acid had been added. α. Corpuscles resembling those in fig. 27. β, β. Escaped nuclei; each consisting of two discs. γ, γ. Corpuscles resembling those in fig. 33; but their compound nuclei separating into discs. δ. Corpuscle exhibiting an orifice in its membrane; the sides of the orifice presenting a finely granular substance. ε. Corpuscle containing three compound globules similar to those in fig. 30; but much more minute. Several of the corpuscles in this figure (fig. 34.) were seen to be filled with enlarged discs or incipient cells. A few of these have been represented in outline.

Fig. 35. Outline of large cells found with those in the preceding figure. Their membranes appeared shrivelled. These cells were filled with altered discs, and more or less incipient cells. Each of their nuclei consisted of many discs, of a deep yellow (reddish) colour. (Such cells were found in blood from another embryo of the Ox, measuring in length $1\frac{1}{4}$ inch.)

PLATE XVIII.

Fig. 36. Sparrow (*Fringilla domestica*, LINN.). Blood-corpuscles, chiefly in outline. It will be observed that two of these are round. Like the rest, however, these two were flattened. Round ones were seen only here and there. α. A group of young corpuscles of the blood. Their colour was the same as that of the other corpuscles in this figure; but they were less flattened. The pellucid space represented in some of these objects (α), indicates the situation of the future nucleus (see the explanation of fig. 43.). β. A blood-corpuscle in which there were observed discs or young cells around the nucleus. The nucleus has not been figured.

Fig. 37. Sparrow (*Fringilla domestica*, LINN.). Blood-corpuscles with their nuclei —both in outline—as seen after the addition of a *minute* quantity of acetic acid. The corpuscles on the left hand, in the figure, had undergone only a partial change in their form from the acetic acid; while those on the right (lying in another part of the field of view) had become globular from this acid. α, α, α. The nucleus has changed its position;

having become in two instances oblique, in another instance situated on one side. β. It is dividing into two parts. γ. This division is complete. δ. From the direction of the nucleus, only one of its extremities is seen. The corpuscle in this instance had lost its flattened form, but not yet become globular.

Fig. 38. Sparrow (*Fringilla domestica*, LINN.). Nuclei of blood-corpuscles, after the removal of the surrounding substance by acetic acid.

Fig. 39. Sparrow (*Fringilla domestica*. LINN.). Two blood-corpuscles filled with discs, or young corpuscles; and two young corpuscles in nearly the same state, but no longer contained within a parent corpuscle (cell). Acetic acid had been added in *minute* quantity.

Fig. 40. Common Fowl (*Phasianus Gallus*, LINN.) in an egg incubated eighty hours. Outline of blood-corpuscles. An orifice is visible in some, and not in others.

Fig. 41. Blood-corpuscles from the same egg, after the addition of acetic acid. They are represented partly in outline. α. The nucleus consists of two discs. β. It is composed of several. γ. Globular corpuscle filled with young corpuscles.

Fig. 42. Common Fowl (*Phasianus Gallus*, LINN.), in an egg incubated eighty-five hours. Outline of blood-corpuscles. (Discs were indistinctly visible in the interior, even before the addition of any acetic acid.)

Fig. 43. From the same egg. Outline of blood-corpuscles, after the addition of acetic acid. α. The corpuscle has an elongated orifice. β. The corpuscle is filled with minute cells. Its finely granular nucleus has a pellucid cavity, communicating with the exterior of the corpuscle (compare this object with the germinal vesicle, Phil. Trans. 1840, Part II. Plate XXII. fig. 159.). This orifice is originally larger. It becomes reduced in size with the appearance of the finely granular substance: the latter preceding the formation of the discs, into which the nucleus is resolved. γ. The nucleus consists of two discs. δ. The nucleus is composed of several discs.

Fig. 44. Common Fowl (*Phasianus Gallus*, LINN.), in an egg incubated ninety-two hours. Outline of corpuscles of the blood.

Fig. 45. From the same egg. Blood-corpuscles, chiefly in outline, after the addition of acetic acid. These were globular, or nearly so, excepting two, which were elliptical. The latter form was not frequent after acetic acid had been added. All the corpuscles in this figure were seen to be filled with discs or incipient cells. α. Corpuscle with a large orifice. β. The nucleus finely granular, with a minute cavity (see the description of fig. 43.). γ. The nucleus as in β; concentric layers of discs or incipient cells around it. δ. The orifice elongated, with an accumula-

tion of finely granular substance beneath it, having a minute central and pellucid cavity (see the description of fig. 43.). ε. The nucleus consists of two discs. ζ. One of the two discs of which the nucleus is composed seems preparing to divide into minuter discs. η. The nucleus consists of three discs. θ. The nucleus is composed of several discs, surrounding a pellucid cavity. ι. The nucleus consists of many discs. κ. Globular corpuscle filled with discs, apparently young corpuscles.

Fig. 46. Common Fowl (*Phasianus Gallus*, Linn.), in an egg incubated 166 hours. Outline of corpuscles of the blood.

Fig. 47. From the same egg. Two blood-corpuscles after the addition of acetic acid. The drawings of the discs, or incipient cells, around the nucleus in these are more finished than those of the corresponding parts in many of the other figures. α. The nucleus consists of two discs. β. It is composed of three objects, each of which seems to be dividing into two discs.

Fig. 48. Turtle. Blood-corpuscles after the addition of acetic acid; some of them in outline. α. The nucleus dividing into two discs. β, β. The nucleus consists of two closely adherent discs. γ. The nucleus is composed of two discs; the one lying across the other.

Fig. 49. Turtle. Blood-corpuscles after the addition of acetic acid; two of them in outline. α. The nucleus is a single disc. In one of these corpuscles there are represented discs or incipient cells. β. Corpuscle beginning to collapse.

Fig. 50. Frog (*Rana temporaria*, Linn.). Blood-corpuscles after the addition of acetic acid; one of them in outline only. α. The nucleus is a single disc. β. The nucleus is dividing into two discs. γ. The nucleus consists of two distinct discs. δ. The nucleus is dividing into three discs. ε. The corpuscle contains many incipient cells. (The nucleus has not been represented in ε.)

Fig. 51. Thornback (*Raia clavata*, Linn.). Blood-corpuscles, after the addition of acetic acid; one of them in outline. Some remained elliptical. α. The nucleus is a single disc. β. The nucleus is dividing into two discs. γ. The nucleus consists of two distinct discs. δ. Minute corpuscle filled with minuter cells; its nucleus consisting of two closely adherent discs. ε. Corpuscle, the nucleus of which consists of two compound globules. Compare with fig. 30 α, and fig. 34 ε.

Fig. 52. Skate (*Raia batis*, Linn.). Blood-corpuscles, after the addition of acetic acid. The larger ones are in outline. (The greater number of the corpuscles seen were of the second and third size.) The corpuscles did not become globular on the addition of acetic acid. α. The nucleus is a single disc, but it is beginning to divide into two. At β this division

has proceeded further. At γ, γ the nucleus is dividing into three parts. In one of the corpuscles γ, are seen, in outline, minute cells. δ, δ. The nucleus consists, in one corpuscle of two, and in another of three, distinct discs.

Fig. 53. Cod (*Gadus Morrhua*, LINN.). Blood-corpuscles after the addition of a *minute* quantity of acetic acid. They are represented for the most part in outline. The sizes and forms most frequent were such as those of the larger corpuscles on the left side in the figure. α. Discs or cell-like objects are contained within the corpuscle, around the nucleus. This was seen to be the case in corpuscles generally throughout the field of view. The nucleus consisted in general of two or more discs. β. Globular corpuscle filled with discs, apparently young blood-corpuscles.

Fig. 54. Cod (*Gadus Morrhua*, LINN.). Blood-corpuscles after the addition of a *minute* quantity of acetic acid. Some of them are in outline only. The objects α, β, γ, δ appeared to be young blood-corpuscles; of which α represents the least advanced, and δ the most forward state (par. 79.). Discs or young cells were seen around the nucleus in all the larger corpuscles of this figure; and indeed in the majority of such of the corpuscles from this individual, as were minutely examined. They were visible in a great number of instances without any addition having been made. The discs in the corpuscle ζ are larger than those in ε; while the nucleus is smaller. At η, the crenate circle represents the outline of a layer of discs or young cells, which surrounded the nucleus. The space external to this layer, seemed to be occupied by red colouring matter.

PLATE XIX.

Fig. 55. Frog (*Rana temporaria*, LINN.). Nuclei of blood-corpuscles, and other objects, observed in the blood, after the addition of acetic acid. α Resembles the compound globules in figs. 30, 33, ε of fig. 34, and ε of fig. 51.

Fig. 56. Nuclei of blood-corpuscles (and other objects?), observed in blood of the same animal, several days dead. These nuclei were no longer contained in cells.

Fig. 57. Oyster (*Ostrea edulis*, LINN.). Objects found in the blood. α. Cell, the nucleus of which consists of two closely adherent discs. Compare this cell with many of the blood-corpuscles from vertebrated animals in Plates XVII. and XVIII. β, β. Globules composed of three or more discs. γ. Globules circumscribed by a membrane-like lamina, and composed of discs resembling those in figs. 30, 33, and ε of fig. 34. from

the Mammal, and ε of fig. 51. from the Fish. δ. Globules composed of discs surrounding a pellucid cavity. Compare with the nucleus of θ in fig. 45. from the Bird. ε, ε, ε. Cup-like objects composed of discs; one of them in outline. ζ. One of the same objects apparently in a more incipient state. Compare the objects ε and ζ with those in fig. 58. from the Turtle.

Fig. 58. Turtle. Cup-like objects observed in the blood, after the addition of acetic acid. Five of them are in outline. Compare these objects with ε of fig. 57. from the Oyster.

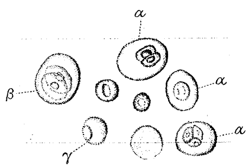
Fig. 59. Ox (*Bos Taurus*, LINN.). Embryo of about one inch in length. Globules and other objects from the brain. They are composed of discs. Compare these objects with some of the nuclei of blood-corpuscles in Plates I. and II. Acetic acid had been added.

Fig. 60. Objects from the Brain of another embryo of the same animal, measuring $1\frac{3}{4}$ inch in length, after the addition of acetic acid. Previously such globules in many instances seemed to be surrounded by the membrane of a minute cell. Compare as in the description of fig. 59.

Fig. 61. Lobster (*Cancer marinus*, LINN.). Corpuscles (partly in outline) observed in the blood, after the addition,—α. of alcohol,—β. of acetic acid.

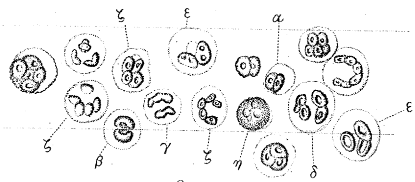
Fig. 62. Leech (*Hirudo medicinalis*, LINN.). Corpuscles of the blood. Some were observed larger than any of those represented in the figure.

Corpuscles of the Blood.



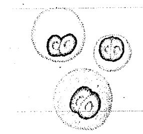
24

Fœtal Ox, $\frac{3}{4}$ Inch.



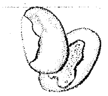
23

Man. — Acetic Acid.



27

Fœtal Ox, $\frac{3}{4}$ Inch.
Acetic Acid.

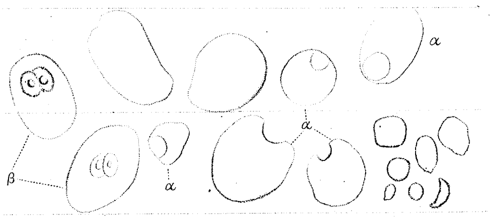


25

Fœtal Ox. $\frac{3}{4}$ Inch.
Incipient Collapse.

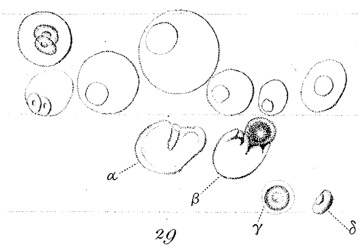
26

Fœtal Ox, $\frac{3}{4}$ Inch.



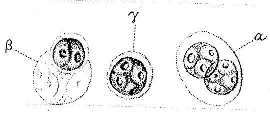
28

Fœtal Ox, 1 Inch.



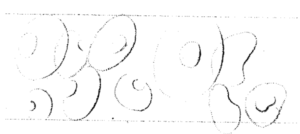
29

Fœtal Ox, 1 Inch. — Acetic Acid.



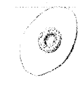
30

Fœtal Ox, $1\frac{1}{4}$ Inch.
Acetic Acid.



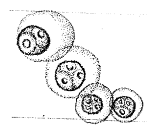
31

Fœtal Ox, $1\frac{3}{4}$ Inch.
Acetic Acid.



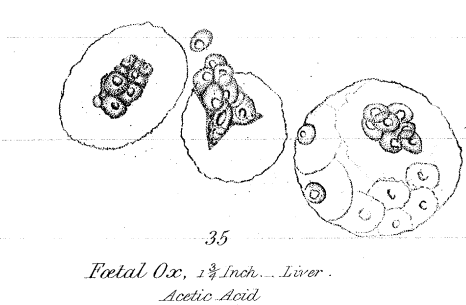
32

Fœtal Ox,
$1\frac{3}{4}$ Inch.



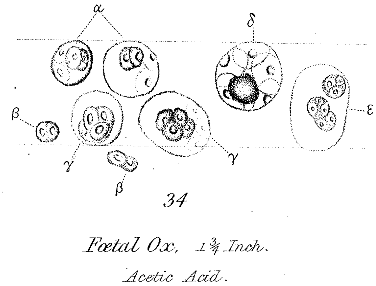
33

Fœtal Sheep. $2\frac{1}{2}$ Inches.
Acetic Acid.



35

Fœtal Ox, $1\frac{3}{4}$ Inch. — Liver.
Acetic Acid



34

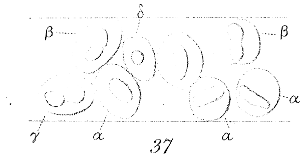
Fœtal Ox, $1\frac{3}{4}$ Inch.
Acetic Acid.

All the objects are seen of their relative sizes, being alike magnified 600 diameters. Their actual sizes may be determined by reference to the spaces they occupy between the horizontal lines, which are $\frac{1}{100}$th of a Paris line apart in the micrometer itself. Thus in Fig. 29. the actual diameter of γ is $\frac{1}{300}'''$ (Paris Line.)

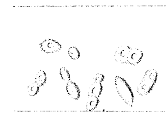
Ad Nat. del. Martin Barry. J. Basire. sculp.

Corpuscles of the Blood.

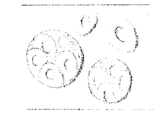
36
Sparrow.



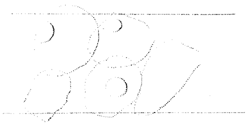
37
Sparrow.
Acetic Acid.



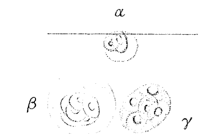
38
Sparrow.
Acetic Acid.



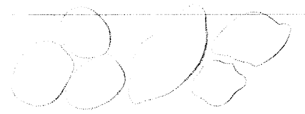
39
Sparrow.
Acetic Acid.



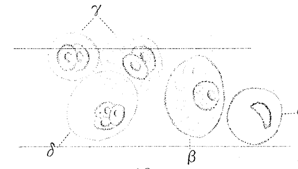
40
Chick in ovo.
80 Hours.



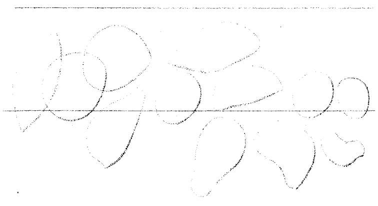
41
Chick in ovo.
80 Hours _ Acetic Acid.



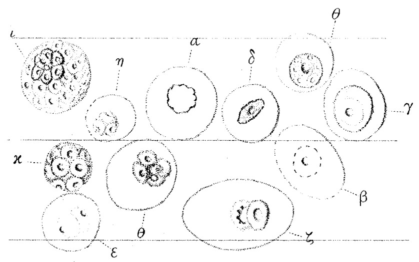
42
Chick in ovo.
85 Hours.



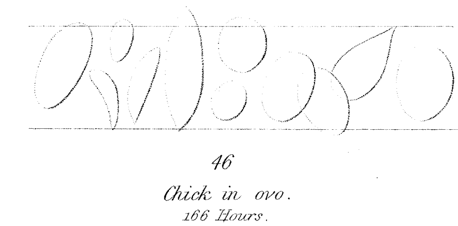
43
Chick in ovo.
85 Hours _ Acetic Acid.



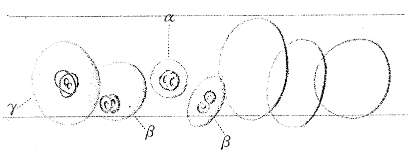
44
Chick in ovo.
92 Hours.



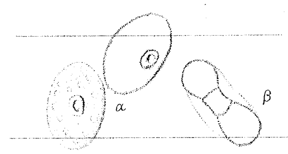
45
Chick in ovo.
92 Hours _ Acetic Acid.



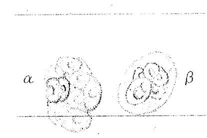
46
Chick in ovo.
166 Hours.



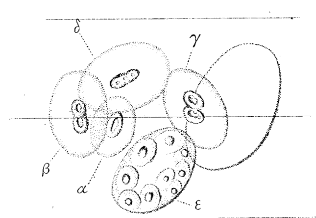
48
Turtle.
Acetic Acid.



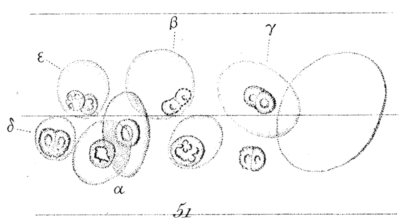
49
Turtle.
Acetic Acid.



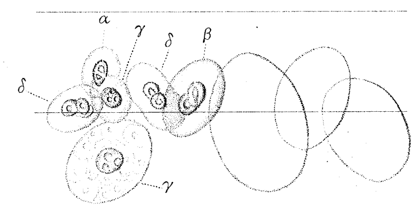
47
Chick in ovo.
166 Hours. Acetic Acid.



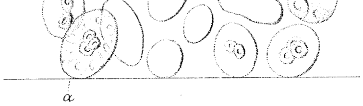
50
Frog.
Acetic Acid.



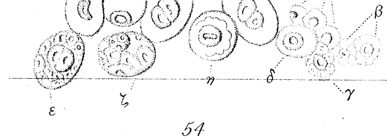
51
Thornback.
Acetic Acid.



52
Skate.
Acetic Acid.



53
Cod.
Acetic Acid.



54
Cod.
Acetic Acid.

All the Objects are magnified 600 Diameters.

(The horizontal Lines are described at the foot of Plate XVII.)

Ad Nat. del. Martin Barry. J. Basire sculp.

Phil. Trans. MDCCCXLI. Plate XIX. p. 216.

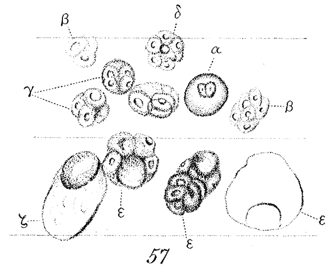
Corpuscles of the Blood.

55

Frog.
Acetic Acid.

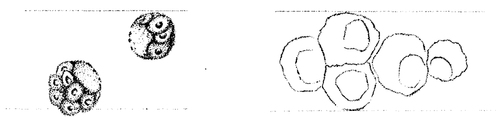
56

Frog.



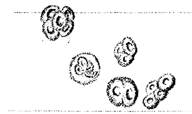
57

Oyster.

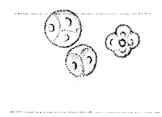


58

Turtle.
Acetic Acid.

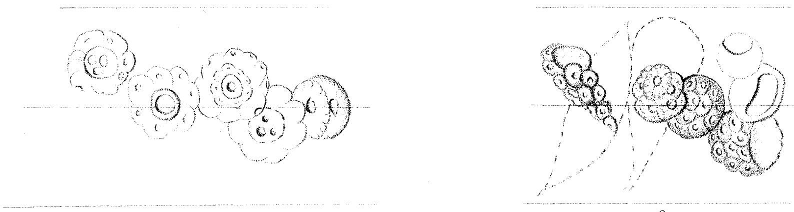


59



60

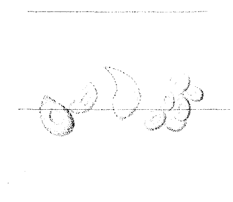
Objects from the Brain, in the Fœtus of the Ox.
Acetic Acid.



α
Dilute Spirit.

61
Lobster.

β
Acetic Acid.

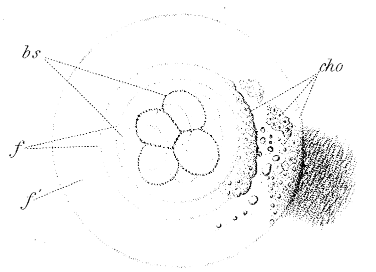


62
Leech.

All the Objects are magnified 600 Diameters.

(The horizontal Lines are described at the foot of Plate XVII.)

Embryology. (see p. 193.)



254

bs The Germ.
f "Zona pellucida".
f' Fluid imbibed by the Chorion.
cho Objects giving origin to the Chorion.

Ad Nat. del. Martin Barry.
J. Basire sculp.