V. *The Blood-corpuscle considered in its different Phases of Development in the Animal Series. Memoir* II.—*Invertebrata.* *By* T. Wharton Jones, *F.R.S., Lecturer on Anatomy, Physiology and Pathology, at the Charing-Cross Hospital, &c.*

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THE invertebrate animals, of which I am here about to consider the blood-corpuscle in its different phases of development, are some of the more readily procurable examples of the divisions Annulosa and Mollusca. The order in which I purpose to proceed is from the higher to the lower classes of each division, an order the contrary of that adopted in the case of the Vertebrata.

Annulosa.

1. My examples of Annulosa are from the classes of Crustacea, Arachnida, Insecta, and Annelida.

Examination of the Blood-corpuscles of Crustacea.

2. As examples of Crustacea I have taken Crabs and Lobsters.

Blood-corpuscles of Crabs.

3. By snipping off the end of one of the legs of a Crab, the blood flows freely out from the stump, and is thus readily obtained*. A small quantity of the blood being received on a plate of glass direct from the animal, and forthwith examined under the microscope, it is seen to contain a very considerable number of corpuscles.

4. *Kinds of Corpuscles.*—Both granule-cells and nucleated cells,—the latter the more numerous,—may be distinctly recognised.

5. *Shape of the Cells.*—If very great expedition has been employed in receiving the blood as it flows from the animal on the plate of glass, spreading it out and transferring it to the microscope for examination, the granule-cells may be seen to be of an elongated oval shape, the nucleated cells spindle-shaped (figs. 1 and 6.). These shapes however are speedily changed.

6. As regards the granule-cell, it tends to become circular (figs. 2 and 3.), but it

* The blood as it flows from the animal appears of a pale reddish gray or neutral tint; when collected in a watch-glass, it separates into a spongy-looking mass and a serous fluid. This spongy-looking mass, which is of a slight pink colour, consists principally of the corpuscles aggregated, there being little spontaneously coagulable material in the plasma to form a true clot. The serous fluid, which is bluish by reflected light, and reddish by transmitted light, is coagulated by heat, and also by *acetic acid*.

is also soon observed that its cell-wall bulges out here and there into round processes which again subside, whilst another part of the cell-wall bulges out in the same way. This change of shape, it will be perceived, is similar to that which I particularly described in the case of the granule-cell of the blood of the Skate, only it is to be remarked, that it is not accompanied by such a well-marked movement of the contained granules. Besides bulging out into round processes, the cell-wall may be seen to shoot out into cilia-like processes also (fig. 4.).

7. As regards the nucleated cell, it also first tends to become circular, and then shoots out its wall into processes which are usually more cilia-like than in the case of the granule-cell; and being in all directions like radii, the cell comes to present a stellate appearance (figs. 7, 8, 9.). Sometimes a cell is seen to shoot out into processes in two principal directions only, these processes again shooting out into smaller, so that the cell acquires a caudate form. Between this shape and the former there is every intermediate degree.

8. *Size of the Cells.*—When first examined, and before their shape has become changed, the granule-cells are about $\frac{1}{1800}$th of an inch long by about $\frac{1}{3600}$th of an inch broad. The nucleated cell is rather less in size, or perhaps with about the same length; it is not quite so broad.

9. *Structure of the Granule-cell.*—There are both coarsely and finely granular stages of the granule-cell. The granules appear more or less fused together, and are of a slightly greenish yellow colour when the microscopical examination is made by day-light.

10. By the addition of water the cell-wall is brought out very distinctly. Imbibing the water, the cell becomes distended and acquires a circular shape, and this as well after it has shot out into processes as when the water is added to the blood just drawn, and before the cell has lost its original shape. Fig. 5 *a.* represents a granule-cell as acted on by water.

11. In consequence of acetic acid producing a copious white curdy precipitate on its addition to the blood, some difficulty was at first experienced in studying the action of that acid on the blood-cells, but by previously diluting the blood with much water, the precipitate was not considerable enough to prevent the observation of the action of the acetic acid on the blood-cells.

12. When the acid comes into contact with the granule-cell, the granulous mass is dissolved, the granules disappearing one after the other, as already described in regard to the granule-cell of the Skate, &c. After the solution of the granulous mass, there is discovered in the interior of the cell, a cellæform nucleus about $\frac{1}{7000}$th of an inch in diameter (fig. 5 *b.*).

13. A clear spot which may be observed on the side of the granule-cell in blood just drawn (figs. 1, 2, 3.), and which is similar to that presented by the granule-cell of the blood of the Skate, appears to be, as in the Skate, produced by the nucleus peering through a pore in the granulous mass.

14. *Structure of the Nucleated Cell.*—By the action of water, the nucleated cell is distended and rendered circular even after it has shot out processes and acquired a stellate appearance. During this action of the water, the processes of the cell-wall may be observed to become broader and shorter, and to run into each other until the outline of the whole cell is circular, as in fig. 10. Within the cell thus distended, the cellæform nucleus is seen circular, and about $\frac{1}{3500}$th of an inch in diameter.

15. By the addition of dilute acetic acid, the nucleated cell is not further materially affected.

16. Although a decided coloured stage of nucleated cell does not exist in the blood of the Crab, it is proper to observe that many of the nucleated cells transmit the light through their interior of a very slight red tint. The circumferential doubling of the cell-wall transmitting the light quite colourless, forms with the interior a well-marked contrast. Though the red tint is more marked by lamp-light, it is sufficiently distinct by day-light. It has been above mentioned, that when the corpuscles collected in a mass are viewed by reflected light, they also appear slightly pink.

17. Besides granule-cells and nucleated cells such as have now been described, cells occur in which the cellæform nucleus is already visible, but still surrounded by some granulous matter (fig. 11.). These may be viewed as cells in a state of transition from granule to nucleated cell.

18. It may thus be concluded, that in Crabs the blood-corpuscle presents itself in two different phases of development, as in the oviparous Vertebrata, viz. the phases of granule-cell and of nucleated cell, the granule-cell being the first phase of development, the nucleated cell the second phase.

19. Floating about amongst the blood-corpuscles, there are seen a few elementary granules, the larger of which, from $\frac{1}{6000}$th to $\frac{1}{12,000}$th of an inch in diameter, have the form of biconcave circular discs.

Blood-corpuscles of the Lobster.

20. The description which has now been given of the blood-corpuscles of the Crab, is in all respects applicable to those of the Lobster*.

Examination of the Blood-corpuscles of Arachnida.

21. It was the *common Spider* the blood of which I examined; and the mode in

* The changes of form which the blood-corpuscles of the Lobster, like those of the Crab, undergo after the blood is drawn, were described and delineated by HEWSON as accurately as his microscope appears to have enabled him to observe them. HEWSON also mentions what I have found to be the case, that the blood of the Lobster, "after being some time exposed to the air, jellies, but less firmly than the blood of more perfect animals." In this respect the blood of the Lobster differs from the blood of the Crabs which I examined; the blood of the latter, as I have above stated, not containing a sufficient quantity of spontaneously coagulable material to form a perfect clot. It may be proper to remark that it was in the beginning of winter when I examined the Crab's blood, and in the beginning of spring when I examined that of the Lobster.

which I obtained the blood was the same as that already stated in regard to the Crab and Lobster, viz. by snipping off one of the legs and receiving on a plate of glass the minute drop of blood which oozed out.

22. The blood-corpuscles of the Spider are almost identical with those of the Crab and Lobster. There are both granule-cells and nucleated cells,—the latter the more numerous,—which when examined immediately on the blood being drawn from the animal, present, the former an oval, the latter an elliptical shape (figs. 1, 2 and 7.). These shapes, however, are in general soon lost. The cells become roundish, their cell-wall at the same time shooting out into processes. This shooting-out of the cell-wall into processes is more especially presented by the granule-cells (fig. 3.), for in the case of the nucleated cell, it might be said that the cell-wall in general rather becomes shrivelled and collapsed than shoots into cilia-like processes (fig. 8.).

23. The size of the corpuscles is much the same as in the Crab.

24. There are both coarsely and finely granular stages of the granule-cell (figs. 1 and 2.), and also cells in transition from the granule to the nucleated phase.

25. By the action of water, the cell-wall of both granule and nucleated cell is distended and brought out in the same way as in the case of the blood-cells of the Crab (figs. 4, 5 and 9.), and by the action of acetic acid the granules of the granule-cells are broken up and dissolved, leaving the nucleus exposed (fig. 6.).

26. In regard to a coloured stage of nucleated cell, what was above said in the case of the Crab (par. 16.), is applicable here.

27. As in the blood of the Crab also, a few elementary granules are seen floating about.

Examination of the Blood-corpuscles of Insecta.

28. In entering on the examination of the blood-corpuscles of insects, the advantage of having first examined those of Crabs and Spiders is strongly felt; for the blood of these animals being readily and certainly obtainable free from admixture with foreign particles, which might be confounded with blood-corpuscles, the characters of their blood-corpuscles will serve as a guide by which to recognise their analogues in the blood of insects and other invertebrate animals, the conformation and structure of the bodies of which are such that we cannot be sure that the blood obtained from them is quite free from foreign admixture.

29. As examples of perfect insects I have taken Beetles, and as examples of chrysalises I have taken those of the Cabbage Butterfly*.

Blood-corpuscles of Beetles.

30. The matter examined as the blood of these insects was the clear greenish

* I have also examined the blood-corpuscles of the Caterpillar, and found them in essential particulars the same. Having, however, as yet obtained but one specimen of a caterpillar of the Cabbage Butterfly, I am not able to give here a description and delineation of the blood-corpuscles. This, however, I shall be able to do on another occasion.

yellow fluid which exuded when a small wound was made in the body of the animal.

31. In this fluid there were recognised, amidst a number of other corpuscles the nature of which will be inquired into below, corpuscles corresponding in essential characters to the granule and nucleated blood-cells of the Crab and Spider.

32. *Granule Blood-cells.*—These were, when seen immediately on the blood being drawn, of an elliptical or oval shape (fig. 1.), but they soon became round. In this state some might be seen with the cell-wall shot out into small cilia-like processes (fig. 2.). By the action of water, the cell becoming distended, these processes disappeared (fig. 3.).

33. The size of the cells under consideration was on an average $\frac{1}{2000}$th of an inch long by $\frac{1}{4000}$th broad.

34. The cells were most of them pale-looking, but some presented coarser and more refracting granules than others.

35. *Nucleated Blood-cells.*—These were much more numerous than the granule blood-cells. When the blood was first examined on being drawn, the cellæform nucleus, of an oval shape, measuring $\frac{1}{3650}$th by about $\frac{1}{7000}$th of an inch, and reddish in its interior, was the part most distinctly seen. The cell-wall, which might sometimes be seen of an elliptical shape (fig. 4.), was in general already found shrivelled and collapsed around the cellæform nucleus, or shot out into processes (fig. 5.). It was extremely pale and not always very readily distinguished. On the addition of water, however, it became distended and was then pretty distinctly seen (fig. 6.). In this state it was circular and measured about $\frac{1}{2000}$th of an inch in diameter.

36. In regard to the other kinds of corpuscles contained in the blood of the Beetle, they were, 1st,—a few corpuscles resembling the cellæform nuclei of the nucleated cells, but around which no cell-wall could be detected; 2nd, some oil-globules; 3rd, a great number of elementary granules in size from about $\frac{1}{7000}$th of an inch in diameter downwards, the larger being biconcave, circular, and of a yellowish or reddish colour.

Blood-corpuscles of the Chrysalis of the Cabbage Butterfly.

37. The matter examined as blood was the clear green fluid which flowed out on slight pressure, when a small point of the anterior end of the chrysalis was snipped off.

38. In this fluid there were both granule-cells and nucleated cells (figs. 7, 8, 9, 10, 11, 12.), together with elementary granules.

Examination of the Blood-corpuscles of Annelida.

39. As examples of Annelida, I have taken the common Earth-worm and the medicinal Leech.

Blood-corpuscles of the Earth-worm.

40. The blood was most readily obtained for examination from the abdominal vessel, but in abstracting it, care was required to guard against its becoming mixed with the secretion poured out from the skin in great abundance when the animal was wounded.

41. The corpuscles of the blood of the Earth-worm are remarkable for their great size, being on an average $\frac{1}{1100}$th or $\frac{1}{1200}$th of an inch in diameter. There are both granule and nucleated cells.

42. *Granule Blood-cells.*—Of these there are both coarsely and finely granular stages. I have not observed the cell-wall of the granule-cell in the coarsely granular stage to shoot out into more than perhaps a single bud-like process (fig. 1.), but in the finely granular stage, the cell-wall shoots out into so many cilia-like processes, that the cell soon after the blood is drawn presents a stellate form (fig. 2.), the granulous mass about $\frac{1}{1800}$th of an inch in diameter occupying the centre.

43. By the action of water the granule-cells become uniformly distended (figs. 3 and 4.), the stellate form into which the cell in the finely granular stage had fallen disappearing. In this state of distention the cells measure $\frac{1}{1100}$th or $\frac{1}{1200}$th of an inch in diameter, but their granulous contents do not fill their whole interior.

44. Acetic acid causes the granules of the cell in the coarsely granular stage to break up, but does not dissolve their substance. The granulous contents of the cell in the finely granular stage it renders more transparent.

45. *Nucleated Blood-cells.*—Instead of perfect nucleated cells, the cells about to be described under this head might, perhaps, rather be said to be cells in transition from the granule-cell phase, inasmuch as the nucleus, though quite evident, is still surrounded by granular matter.

46. The cells under consideration have always been collapsed when first seen, though the blood was examined as quickly as possible after being drawn; but I have observed them in the act of shooting out their cell-wall into processes (fig. 5.), like the granule-cell in the finely granular stage.

47. By the action of water, the processes are made to disappear by the cell becoming uniformly distended. In this state the cell measures about $\frac{1}{1100}$th of an inch in diameter, and in its interior is seen the cellæform nucleus about $\frac{1}{3600}$th of an inch in diameter, with a finely granulous mass surrounding it (fig. 6.). This granulous mass is not dissolved entirely by acetic acid, but it is rendered more transparent.

48. The red colour of the blood of the Earth-worm is, as is known, seated in the plasma, but it is to be remarked that some of the nucleated cells appear very slightly tinged, as also the nuclei, in their interior.

49. Besides the nucleated cells now described, corpuscles are met with altogether like their nucleus and its surrounding granulous mass, both in form and size.

50. Lastly, there are a few corpuscles like perfectly free nuclei, and a considerable number of elementary granules, the larger, of the form of biconcave circular discs.

Blood-corpuscles of the Medicinal Leech.

51. The blood examined was obtained by making incisions on the back or side of the animal after having carefully wiped the surface of the skin. In making these incisions care was taken not to cut into the stomach, or its cæcal appendages, in order to obviate the possibility of foreign blood which might have been taken in as food, becoming mixed with the real blood of the animal itself.

52. In the first place it is worthy of remark, that whilst the corpuscles of the blood of the Earth-worm are the largest which I have yet found in any invertebrate animal, the corpuscles of the blood of the Leech are the smallest.

53. When the blood of the Leech is examined under the microscope as soon after its abstraction from the animal as possible, numerous corpuscles are seen having the appearance of very pale, shining, colourless, fusiform filaments, about $\frac{1}{2000}$th of an inch in length, and about $\frac{1}{7000}$th of an inch in breadth, less or more (fig. 9.), suspended in the red-coloured plasma. Very soon, however, the corpuscles are seen gradually to become shorter and somewhat broader, until at last they acquire an irregular circular form (fig. 10.).

54. In this state the majority of the corpuscles appear to be composed of a nucleus surrounded by a collapsed and shrivelled cell-wall. And that this is so, is reduced to a certainty by the addition of water, which causes the cell to become distended and to acquire a circular form, whilst the outline of the cellæform nucleus appears more distinctly defined (figs. 11 and 12.).

55. Thus distended, the cell is from $\frac{1}{3000}$th to $\frac{1}{3600}$th of an inch in diameter, and the nucleus $\frac{1}{7000}$th, or more.

56. Many of the cells transmit the light slightly tinged red, as if there was some colouring matter lining their interior (fig. 12.).

57. The corpuscles of the blood of the Leech now described, it will have been observed, are *nucleated cells*.

58. *Granule-cells.*—Corpuscles in the blood of the Leech referrible to this head are few in number. Examples of them are delineated in figs. 7 and 8*.

* I subjoin here a description of the corpuscles of the blood vomited by leeches which have never been used. This blood I found to be composed of a coloured plasma, and numerous corpuscles having a considerable resemblance to those of the blood of the animal itself after having lost their original fusiform shape, and become somewhat distended by water. On the whole, however, the corpuscles of the blood in question were somewhat larger, and appeared perhaps better defined than those of the Leech itself, especially the granule-cells, which were also more numerous, though still not so numerous as the nucleated cells.

Of the granule-cell there were both coarsely and finely granular stages (figs. 13 and 14.). There were cells in transition from the granule to the nucleated phase (fig. 15.). The nucleated cells (figs. 16, 17 and 18.) were most of them circular, but some were oval. Most appeared tinged red in their interior, those which did not had their cell-wall so very pale that it was apt to be overlooked.

The blood contained in the stomach of leeches which have not been used, and of which I have now briefly described the corpuscles, from what animal is it derived? The resemblance of the blood to that of the animal itself suggests the probability that medicinal leeches suck the blood of some other kind of leech. That they suck each other's blood has been positively denied by Dr. Rawlins Johnson.

MOLLUSCA.

59. My examples of Mollusca are confined to the classes of Gasteropoda and Acephala,—from the former I have taken the Whelk (*Buccinum magnum*),—from the latter the Mussel (*Mytilus edulis*), in which to examine the blood-corpuscles.

Blood-corpuscles of the Whelk.

60. The shell having been broken to pieces from around the animal, the blood was readily obtained from the great vessels of the heart, or from the heart itself; but notwithstanding every care in abstracting it, the blood was not always quite free from admixture with foreign particles, such as ciliated epithelium-cells and the like.

61. *Kinds of Corpuscles.*—There were granule-cells and nucleated cells essentially similar to those of the blood of Annulosa.

62. *Granule-cells.*—By the time the blood could be examined, the granule-cells had, for the most part, become agglomerated together in groups, and their cell-wall was seen already shot out into processes (fig. 1.).

63. Both coarsely and finely granular stages of the granule-cell were to be recognised.

64. The size of the granule-cell was on an average from $\frac{1}{3000}$th to $\frac{1}{2000}$th of an inch.

65. By the action of water the cell became uniformly distended (fig. 2.), to the size of about as much as $\frac{1}{1500}$th of an inch in diameter and then burst, the cell-wall disappearing and leaving the granulous contents in a mass with the nucleus visible in the centre (fig. 3.).

66. *Nucleated cells.*—Some of these were seen with the cell-wall shot out into processes (fig. 4.); some not (figs. 5, 6 and 7.).

67. Those cells of which the cell-wall did not shoot out into processes, were for the most part circular (figs. 5 and 6.); but some also occurred which appeared to be elliptical (fig. 7.), though these might have been circular cells seen somewhat raised up on edge. The cells under consideration often presented a finely granulous matter in their interior, and some were slightly tinged of a red colour. Their size was about $\frac{1}{2500}$th of an inch in diameter.

68. Those cells of which the cell-wall shot out into processes, when uniformly distended by water, were larger, measuring about $\frac{1}{1650}$th of an inch in diameter (fig. 4 *a*.).

69. The nucleus, oval or circular, and reddish in the interior, measured on an average from $\frac{1}{4800}$th to $\frac{1}{3650}$th of an inch, these being the means when the nucleus was oval.

70. Besides the corpuscles now described, there were a few like free nuclei, and a great quantity of elementary granules of different sizes, the larger biconcave and circular.

Blood-corpuscles of the Mussel.

71. The way in which I obtained the blood of the Mussel was this:—I first removed one valve of the shell with as little injury to the animal as possible, and allowed the contained fluid to drain away; I then opened the great vessel proceeding from the heart to the anterior part of the body, and introducing the microscopical forceps towards the heart, took up enough of the blood for one examination. Notwithstanding this careful procedure, the blood was often mixed with foreign corpuscles, such as the spermatozoa and ova of the animal.

72. *Kinds of Blood-corpuscles.*—There were in the first place *granule-cells*, which, like those of the blood of the Whelk, were found by the time the blood could be examined, already for the most part agglomerated together, and presenting their cell-wall shot out into processes (figs. 1 and 2.). The granulous contents appeared as if fused, forming a clear, more or less strongly refracting mass.

73. By the action of water this mass was broken up into separate granules, and at the same time the cell was observed to become gradually distended and rendered uniformly circular by the undoing of the processes into which its wall had shot. This undoing of the processes I have often, as in the case of the blood-cells of other animals, watched step by step.

74. When the cell had become fully distended, the granulous contents were usually next seen to escape by the bursting of the cell-wall, and to accumulate around its outside, whilst a nucleus from about $\frac{1}{7000}$th to $\frac{1}{4000}$th of an inch in diameter, and now for the first time seen, remained in the interior; the cell-wall, different from that of the granule-cell of the Whelk, continuing quite visible and otherwise entire (fig. 3.).

75. Such was the condition in which the granule-cells presented themselves in the blood of fresh mussels. In the blood of mussels which had been kept for some days in the house without food or change of water, but still alive though weak, the granule-cells were found, for the most part, to continue uniformly distended after the blood was drawn, their cell-wall not shooting out into processes (figs. 4 and 5.). The contents appeared at the same time more broken up into granules. In this state the size of the cells was from $\frac{1}{1800}$th to $\frac{1}{2000}$th of an inch in diameter. They appeared in both coarsely and finely granular stages.

76. Cells in which the nucleus is already distinctly visible without the application of any reagent, were few in number in the blood of perfectly fresh mussels, but in the blood of mussels which had been kept some days, they presented themselves in considerable numbers (figs. 9, 10, 11 and 12.).

77. The corpuscles in which a nucleus had thus become distinctly visible were, as they occurred in the blood of fresh mussels, distinguished by the following characters:—Circular but sometimes ovoid, somewhat prominent in the middle, with a uniform and strongly marked contour, of an opaline aspect, and measuring on an average about $\frac{1}{2400}$th of an inch in diameter, many being both smaller and larger (figs. 6 and 7.).

78. By the action of water the contents of these corpuscles, previously homogeneous looking, adherent to the cell-wall, and concealing the nucleus, became broken up into granules, so that the cell-wall and a nucleus came more or less distinctly into view, with characters similar to those presented by them after the animals had been kept some time as above mentioned, and which I now proceed to describe (fig. 8.).

79. The cell was generally circular but sometimes oval, and its wall did not shoot out into processes. It measured on an average $\frac{1}{2400}$th of an inch, some more, some less.

80. The nucleus was circular or oval. In the former case it measured about $\frac{1}{3600}$th of an inch in diameter, in the latter, the mean of the two diameters was on an average the same as this. Some were much elongated but narrow, others short but broad.

81. The circular cells had the nucleus either circular or oval, but when the cell was oval the nucleus was oval also, and usually elongated and narrow. Sometimes the oval nucleus appeared almost free, the cell-wall very much contracted, being attached to one side only.

82. In addition to the corpuscles now described, there were observed corpuscles very pale and few in number, apparently the nuclei of the nucleated cells become free and in process of disappearing.

83. Lastly, there was a great number of elementary granules; the larger, of the form of biconcave circular discs, measuring on an average $\frac{1}{6000}$th or $\frac{1}{7000}$th of an inch in diameter, less or more.

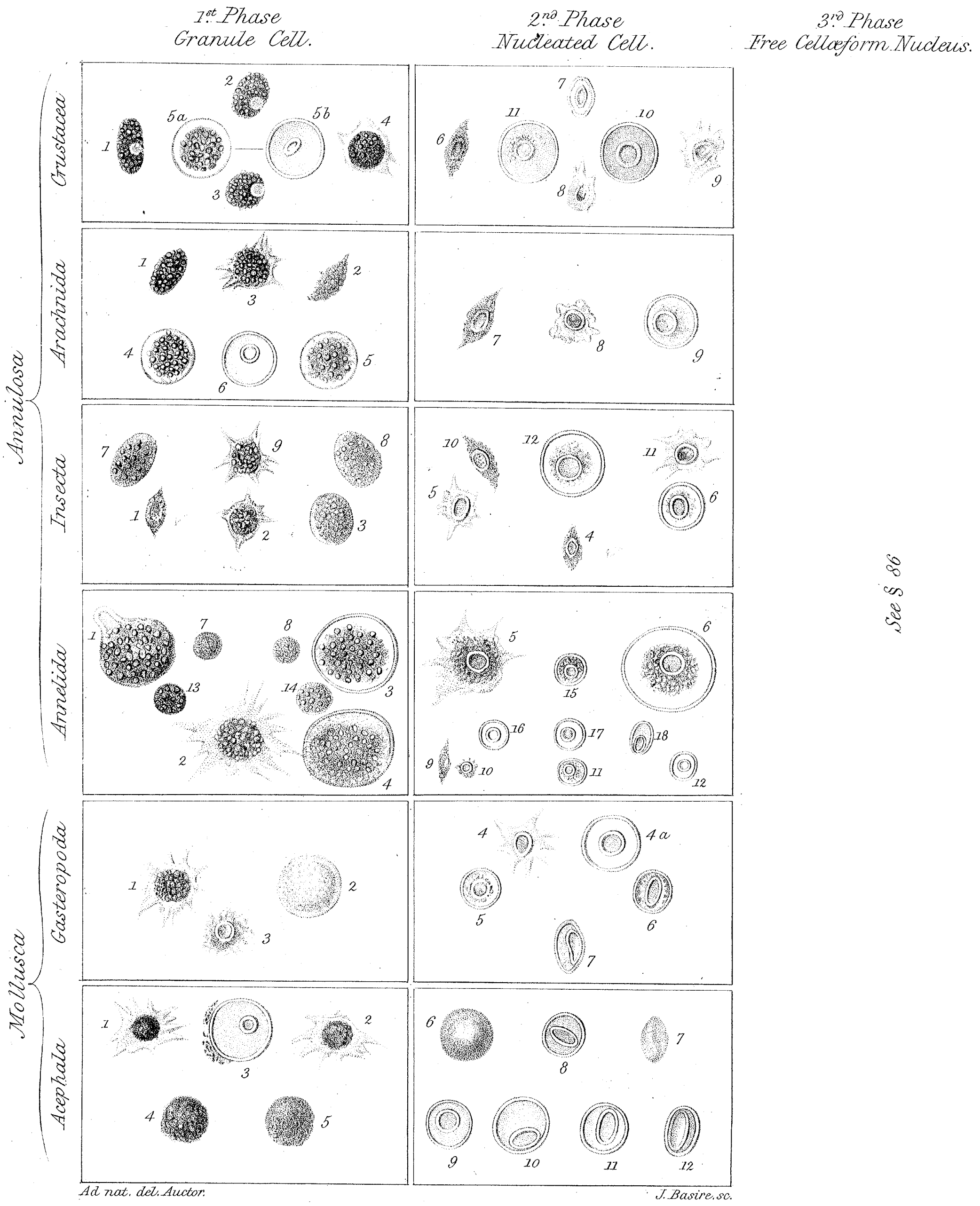
84. It thus results that in all the invertebrate animals in which the blood has now been examined, the blood-corpuscle presents itself in the phases of granule-cell and of nucleated cell; that in the phase of granule-cell it occurs in more or less well-marked coarsely and finely granular stages; that in the phase of nucleated cell it occurs in the uncoloured stage; but that as regards a coloured stage, though such cannot be said to be altogether wanting in some of the animals, the coloration of the cell is in a very slight degree. The cellæform nucleus is found more frequently and more decidedly coloured.

85. It also results that corpuscles exist in transition from the phase of granule-cell to that of nucleated cell.

86. It farther results that corpuscles occur in the blood of some of the animals, which appear to be the nuclei of the nucleated cells become free. Such, however, are to be viewed as abortions rather than as examples of a third phase, or phase of free cellæform nucleus.

87. Lastly, it results that corpuscles are met with in greater or less numbers belonging to the category of the lowest forms of organic elements, viz. elementary granules.

The Blood corpuscle in its different Phases of development in Invertebrate Animals.



NB. All the objects here delineated are magnified 550 diameters.

The microscope a compound one by Ross.— the object glass 1/8th inch.

Explanation of the Plate.

PLATE II.

ANNULOSA.

Crustacea.—Crabs.

First Phase.—Granule-cell.

Fig. 1. Granule-cell as it appears when the blood is examined immediately on being drawn.

Figs. 2 and 3. Granule-cells changed in shape as they appear very soon after the blood has been drawn.

Fig. 4. Granule-cell, with the cell-wall in view at the circumference, and shooting out bud-like processes here and there.

Fig. 5 *a*. Granule-cell after being acted on by water.

Fig. 5 *b*. Granule-cell after being acted on by acetic acid. The granules have all disappeared by solution, and a small cellæform nucleus has thus come into view.

Second Phase.—Nucleated Cell.

Fig. 6. Nucleated cell as it appears when the blood is examined immediately on being drawn.

Figs. 7, 8, 9. The nucleated cell in different degrees of change of shape.

Fig. 10. Nucleated cell after being acted on by water.

Fig. 11. Another, after being treated in the same way, but still presenting some remains of the granules of the first phase, and a smaller cellæform nucleus than the preceding.

Arachnida.—Spider.

First Phase.

Fig. 1. Granule-cell, coarsely granular stage.

Fig. 2. Granule-cell, finely granular stage; both as seen when the blood was examined immediately on being drawn.

Fig. 3. Granule-cell changed in shape, and with the cell-wall shot out into processes.

Figs. 4 and 5. Granule-cells in coarsely and finely granular stages distended by water.

Fig. 6. Granule-cell after the granules have been dissolved by acetic acid.

Second Phase.

Fig. 7. Nucleated cell as it appeared when the blood was examined immediately on being drawn.

Fig. 8. The same, changed in shape, as it appeared soon after the blood was drawn.

Fig. 9. The same, distended by water.

Insecta.—Beetle.

First Phase.

Fig. 1. Granule-cell as it appeared when the blood was examined as soon as possible after being drawn.

Fig. 2. The same, changed in shape—the cell-wall shot out into processes—as it appeared soon after the blood was drawn.

Fig. 3. The same, after the action of water.

Second Phase.

Fig. 4. Nucleated cell, as it may sometimes be seen when the blood is examined immediately on being drawn.

Fig. 5. The same cell, changed in shape. The cell-wall extremely pale, shrivelled, and shot out here and there into processes.

Fig. 6. The same, distended by water.

Insecta.—Chrysalis of Cabbage-butterfly.

First Phase.

Figs. 7 and 8. Granule-cells in coarsely and finely granular stages.

Fig. 9. Granule-cell, with the cell-wall shot out into processes.

Second Phase.

Fig. 10. Nucleated cell of its original shape.

Fig. 11. The same, with the cell-wall shrivelled and shot out into processes.

Fig. 12. The same, distended by water.

Annelida.—Earth-worm.

First Phase.

Fig. 1. Granule-cell, coarsely granular stage. The cell-wall shot out into a single bud-like process.

Fig. 2. Granule-cell, finely granular stage. The cell-wall shot out into cilia-like processes.

Figs. 3 and 4. The same cells distended by water.

Second Phase.

Fig. 5. Nucleated cell with its cell-wall shot out into processes.

Fig. 6. The same, distended by water.

Annelida.—Medicinal Leech.

First Phase.

Figs. 7 and 8. Granule-cells.

Second Phase.

Fig. 9. Nucleated cell as seen when the blood is examined immediately on being drawn.

Fig. 10. The same, changed in shape, as it appeared soon after the blood is drawn.

Figs. 11 and 12. Nucleated cells distended by water.

Blood vomited by Medicinal Leech.

Figs. 13 and 14. Granule-cells, coarsely and finely granular stages.

Fig. 15. A transition cell.

Figs. 16, 17 and 18. Nucleated cells.

MOLLUSCA.

Gasteropoda.—Whelk.

First Phase.

Fig. 1. Granule-cell, with the cell-wall shot out into processes.

Fig. 2. The same, distended by water.

Fig. 3. The contents and nucleus of the same, set free by the bursting of the cell-wall.

Second Phase.

Fig. 4. Nucleated cell, with the cell-wall shot out into processes.

Fig. 4 *a*. The same, distended by water.

Figs. 5, 6 and 7. Nucleated cells, the cell-wall of which did not shoot out into processes.

Acephala.—Mussel.

First Phase.

Figs. 1 and 2. Granule-cells, coarsely and finely granular stages, with the cell-wall shot out into processes.

Fig. 3. Granule cell after the action of water.

Figs. 4 and 5. Granule-cells from a mussel which had been kept some time in the house.

Second Phase.

Figs. 6 and 7. Cells from the blood of fresh mussels, by the action of water on which a nucleus has been rendered visible, as in fig. 8.

Figs. 9, 10, 11, 12. Nucleated cells found in considerable number in the blood of mussels kept some time, but few in number in fresh mussels.