VI. *The Blood-corpuscle considered in its different Phases of Development in the Animal Series. Memoir* III.—*Comparison between the Blood-corpuscle of the Vertebrata and that of the Invertebrata.*

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1. In instituting a comparison between the blood-corpuscle, in its different phases of development, of the Vertebrata and that of the Invertebrata, it is obvious that the examples first taken for the purpose ought to be selected from the lowest class of the oviparous Vertebrata on the one hand, and from the highest class of the highest division of the Invertebrata on the other.

2. In accordance with this I proceed to compare together the blood-corpuscles of the Skate and Crab.

Comparison between the Blood-corpuscle of the Skate and that of the Crab.

3. From the observations above related, it results that the blood-corpuscle of the Crab resembles that of the Skate in presenting two different phases of development, viz. the phase of granule-cell and the phase of nucleated cell, and that in these two phases respectively the essential points of structure are the same.

4. The blood-corpuscle of the two animals, however, differs in the degree of development which it attains in the phase of nucleated cell. In the Crab its development is arrested at the uncoloured stage, or at the most at the commencement of the coloured stage. But this absence of nucleated cells in the decided coloured stage in the blood of the Crab, it has been seen is a peculiarity which there is reason to believe is presented by one at least from among oviparous vertebrate animals, viz. *Branchiostoma lubricum*.

5. The blood of this fish may therefore be admitted as probably differing but little in the character of its corpuscles from the blood of the Crab, and as constituting in this respect a transition from the Vertebrata to the Invertebrata.

6. Having thus compared the blood-corpuscle of an animal from the lowest class of oviparous Vertebrata with that of one from the highest class of the highest division of the Invertebrata, we are prepared to institute a comparison between the blood-corpuscle of the oviparous Vertebrata generally, and that of the Invertebrata from Crabs to Mussels.

Comparison between the Blood-corpuscle of the oviparous Vertebrata generally, and that of Invertebrata.

7. In the oviparous Vertebrata, from the Skate upwards, it has been seen that the blood-corpuscle in its different phases of development is essentially similar to that of the Skate. In the Invertebrata, from the Crab down as far as we have gone, it has also been seen that the blood-corpuscle in its different phases of development is essentially similar to that of the Crab. The only difference therefore in essential respects between the blood-corpuscle of the oviparous Vertebrata generally and that of the Invertebrata, is the same as that between the blood-corpuscle of the Skate and Crab, viz. that in the phase of nucleated cell, the latter does not attain to a decidedly coloured stage.

8. Hitherto I have altogether excluded the blood-corpuscle of the Mammifera from comparison with that of the Invertebrata; but such comparison I now proceed to make.

Comparison between the Blood-corpuscle of Mammifera and that of Invertebrata.

9. In the phase of granule-cell, the blood-corpuscle of the Mammifera and that of Invertebrata resemble each other in essential points of structure. In the phase of nucleated cell they also agree in the absence of a decided coloured stage; in this respect differing from the blood-corpuscle of the oviparous Vertebrata generally and of the early mammiferous embryo.

10. But here the resemblance between the blood-corpuscle of the Mammifera and that of the Invertebrata ceases. In common with the blood-corpuscle of the oviparous Vertebrata, that of the Invertebrata differs from the blood-corpuscle of the Mammifera in not attaining to a decided third phase. The free cellæform nuclei which appear to exist in the blood of some of the Invertebrata, it has been above stated, can only be considered as abortions of such a phase*.

* From neglecting the precautions above observed in instituting a comparison between the blood-corpuscles of the Vertebrata and those of the Invertebrata, Mr. Newport, in a communication recently made to the Royal Society, appears to me to have fallen into a very serious error, as to what corpuscles in the blood of insects and other Invertebrata are analogous to the "red blood-corpuscles" of the Vertebrata.

Overlooking altogether even the well-known differences between the "red blood-corpuscles" of the Mammifera and those of the oviparous Vertebrata, he assumes the "red blood-corpuscle" of the Mammifera as a standard by which to recognise in the blood of insects and other Invertebrata, any corpuscles which may be the analogues of the "red blood-corpuscles" of the Vertebrata generally.

Accordingly, finding in the blood of insects the elementary granules described in Memoir II. of this series of papers, pars. 19, 27, 36, 38, &c., and not being acquainted with the true nature of such particles, he has been misled by their similarity to his assumed type of "red blood-corpuscles," especially in respect of outward form, which is that of biconcave circular discs, into the conclusion that they are the analogues of the "red blood-corpuscles" of the Vertebrata.

The corpuscles in the blood of insects and other Invertebrata which, though little or not at all coloured, I have

11. It was at one time supposed that the red colour of the "red blood-corpuscles" of the Vertebrata is dependent on the iron which they contain, but latterly chemists have come to the conclusion, that though iron is essential to the "red corpuscles," it is not so to their colouring matter.

12. In reference to this question, it occurred to me that it would be interesting to ascertain whether the corpuscles of the blood of an invertebrate animal, notwithstanding their slight degree or total want of colour, contain iron.

13. Accordingly I collected some of the corpuscles of the blood of the Crab, which it is easy to do in consequence of the mode in which they collect together after the blood is drawn, as described in Memoir II. of this series, and in consequence of the plasma not coagulating. These I dried carefully and sent to my friend Professor GRAHAM, who was so kind as to undertake to test them for iron.

14. The annexed letter, from Mr. GRAHAM, will show that the blood-corpuscles of the Crab, though but slightly coloured, do contain iron.

"DEAR JONES,

"I should have communicated sooner the result of the examination of the white corpuscles of the blood of the Crab, of which you sent a small quantity in a dried state, amounting to two or three tenths of a grain. It is that they contain a sensible quantity of iron, perhaps as much as red corpuscles.

"Yours, dear Sir,
"Most truly,
"THOMAS GRAHAM."

"*University College, Nov.* 29, 1844."

15. Of course the presence of iron in the corpuscles of the blood of the Crab is not alone a proof that the red colour of the "red corpuscles" of the blood of the Vertebrata is not owing to iron; it is merely a proof that iron in equal quantity may exist in corpuscles without imparting to them a decided red colour, such as is presented by the "red corpuscles" of the blood of the Vertebrata*.

Comparison of the Corpuscles of the Blood of the Invertebrata with the Corpuscles of the Lymph of the Vertebrata.

16. In the very respect in which the blood of the Invertebrata differs from that of the oviparous Vertebrata generally, viz. the absence of nucleated cells in the decidedly coloured stage, it resembles their lymph† (Memoir I., pars. 101 to 105.).

shown to be the true analogues of the "red blood-corpuscles" of the *oviparous* Vertebrata, viz. the nucleated cells, Mr. NEWPORT considers to be an early stage of the corpuscles which I have described in the same blood under the name of granule-cells, the former, according to him, becoming the latter by the development and accumulation of granules in their interior.

When thus filled with granules, the cells, he appears to believe, burst, and the granules, thus set free, become the alleged analogues of the "red corpuscles" of the Vertebrata.

* The coloured plasma of the blood of the Crab gave unquestionable indications of iron.

† This conclusion, it is to be particularly observed, is to be distinguished from a view first promulgated by

To complete the history of the blood-corpuscle, it remains to inquire into the first formation of the granule blood-cell on the one hand, and into the ultimate fate of the nucleated blood-cell of the Invertebrata, and of the oviparous Vertebrata, and of the free cellæform nucleus of Man and the Mammifera on the other; and also to collate the views given of the development of the blood-corpuscle with the theory of cell development in general.

In executing this task I shall have an opportunity of considering several questions which have suggested themselves in the present series of papers, but which it would have been premature to have entered upon.

Professor Rudolph Wagner, viz. that the corpuscles of the circulating fluid of the Invertebrata are not any of them analogous to the red blood-corpuscles of the Vertebrata, but are all of them analogous to the corpuscles of the lymph, or chyle merely, and that therefore the circulating fluid of the Invertebrata is "mere chyle, not proper blood," proper blood being, as he defines it, "a red coloured fluid containing characteristic corpuscles."

This view appears to me to be distinction without essential difference, and to have arisen,—1st, from an imperfect acquaintance with the corpuscles of the lymph of the Vertebrata, and their relationship to those of the blood of the same division of animals on the one hand, and with the corpuscles of the circulating fluid of the Invertebrata on the other; 2ndly, from laying too much weight on the presence or absence of colour as a distinctive character; thus making no distinction between the "red corpuscle" of the blood of the Mammifera, and the "red corpuscle" of the blood of the oviparous Vertebrata in consequence of their similarity in colour, though there is between them an essential organic difference; whilst between the "red corpuscle" of the blood of the oviparous Vertebrata and the nucleated cell of the circulating fluid of the Invertebrata, in consequence of a supposed total absence of colour in the latter, a decided distinction is made, though there is, in fact, between them no essential organic difference.

Waiving, however, the organic difference between the "red corpuscle" of the Mammifera and the "red corpuscle" of the oviparous Vertebrata, and the organic resemblance between the "red corpuscle" of the oviparous Vertebrata, and the little or not at all coloured nucleated cell of the circulating fluid of the Invertebrata, I would observe in regard to the presence or absence of colour, that nothing bearing on the question can be inferred from it, even in a physiological point of view, seeing that the nature and use of the red colouring matter of the "red blood-corpuscles" are as yet too little known.

The colour of "red blood-corpuscles" is now acknowledged not to be owing to the iron entering into their composition, and therefore it is not, as has been supposed, a manifestation of the existence of any endowment which may be possessed by the "red corpuscles" by virtue of the iron which they contain. But even if this had been so, the fact above mentioned, of the presence of iron in the uncoloured or but little coloured corpuscles of the blood of the Crab, renders it extremely probable that what endowment soever may be possessed by the "red corpuscles" of the Vertebrata by virtue of the iron which they contain, may be equally possessed by the corpuscles of the blood of the Crab.

Professor Wagner adduces arguments of another kind in corroboration of his view, that the circulating fluid of the Invertebrata is "mere chyle, not proper blood;" but which it is scarcely necessary to notice after what I have just said, especially as their force, so far as it is evident, appears to bear more against than in favour of his view.