Original Articles.

THE ORIGIN AND NATURE OF THE BLOOD PLATES.

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A PROLONGED study of the comparative morphology of the blood corpuscles of a wide range of animals has shown me that all of the many theories hitherto proposed concerning the origin and nature of the blood plates are untenable and erroneous.

In this paper I shall not set forth my reasons for coming to this conclusion, but I shall confine myself to a brief statement of my own opinions concerning the origin and nature of these bodies and a summary of the facts and observations upon which my opinions are based.

By means of a staining fluid,[1] devised by me for use in the staining of blood films according to the method of Leishman, which gives the so-called Romanofsky polychrome staining, I have been enabled to stain characteristically the blood plates in sections of fixed tissues and organs so that they may be positively recognized and may be clearly distinguished from other histological elements. The description of the method of obtaining suitably stained sections with this fluid is reserved for a later publication.

After an extensive study of sections of bone marrow and other tissues in which the blood plates are thus characteristically stained, I have convinced myself that the blood plates are detached portions of the cytoplasm of those giant cells of the bone marrow and spleen which have been named "megakaryocytes" by Howell to distinguish them from the multinucleated giant cells of the marrow — the so-called osteoclasts or polykaryocytes (Howell).

This idea of the origin and nature of the blood plates is based upon the following observations:

In the sections, the blood plates (Figs. 7, 11 and 12) present the following characteristics: They appear as small bodies of generally circular outline, of a variable diameter but usually less than that of an erythrocyte; a striking characteristic is the presence in the central part of each plate of an aggregation of more or less closely packed, minute, red to violet stained granules which may be so closely packed together and so deeply stained as to form an opaque, homogeneous, sharply outlined mass giving an appearance suggestive of a nucleus. In this central portion of the plates of some animals small, rounded, unstained, vacuole-like areas are often present. The marginal portion of the blood plate is translucent, blue stained and, though sometimes having a smooth edge, it usually presents at the periphery indentations and short projections of irregular shape giving the edge an irregular or jagged or fimbriate outline. There is thus to be distinguished in the blood plate two portions, namely, a central, granular, red to violet staining portion and a marginal, homogeneous, hyaline, blue staining portion. The diameter of the central portion and the width of the marginal portion vary, the latter being usually narrower than the diameter of the former.

The giant cells present the following peculiarities which are of importance for the subject of this paper:

The cytoplasm making up the central and usually the greater portion of the giant cell is crowded more or less densely with closely set, minute, red to violet granules, for the most part like those of the central portions of the blood plates, while at the periphery it is hyaline and blue stained. This hyaline peripheral portion forms a definite narrow zone of somewhat variable width, but is very narrow as compared with the diameter of the whole cell and has a smooth or finely ragged or fimbriate edge. In appearance it suggests the ectosarc of an ameba. The majority of the giant cells are of spherical form, but a minority are of varied and irregular shape by reason of the distortion of their cytoplasm into processes and pseudopod-like prolongations of varying length, form and width, so that they present all the varieties of form and outline shown by a motile ameba (Figs. 1, 2, 6, 10 and 13).

Some giant cells may be observed in which nearly all of the cytoplasm is in form of pseudopod-like processes extending peripherally in various planes from a small central mass of cytoplasm surrounding the nucleus (Figs. 4 and 14). In these distorted giant cells the central red to violet granular portion of the cytoplasm is continued into the pseudopod-like processes to form in them a central portion, and the peripheral, hyaline, blue, marginal zone also continues on to these processes as a hyaline marginal zone with a smooth, or finely ragged, or fimbriate free edge (Figs. 1, 2, 4, 6, 10, 13 and 14). These pseudopods of the giant cells may have in some instances a greater length than the diameter of the field of an oil immersion objective. Their width is never less than the diameter of the smaller blood plates. They may be seen sometimes projecting far into the lumen of a blood vessel through its imperfect wall (Figs. 1, 6, 10 and 13). Some of them are seen unconnected with any giant cells (Figs. 3, 5, 7, 8, 9, 11 and 12), and such free pseudopods have been found not only in the blood channels of the marrow and spleen, but also in the capillaries of the lungs.

A comparison of these pseudopods, especially the slender ones, with the blood plates shows the most striking similarity in composition and structure (Figs. 5, 7, 8, 11 and 12). The material constituting the granular, red to violet staining, central portion is like the granular, red to violet staining, central portion of the plates in color, texture and general appearance. It may also contain small, round, unstained, vacuole-like spaces like those seen in the central portions of the plates (Figs. 5, 7, 11 and 14). The hyaline

[1] A Rapid Method for the Differential Staining of Blood Films and Malarial Parasites, by James Homer Wright, M.D., Journ. Med. Research, vol. vii, p. 138, January, 1902.
Pathological Technique, by Mallory and Wright, third edition, p. 370. Saunders, Philadelphia, 1904.

marginal zone of the pseudopod is also just like the marginal hyaline portion of the plate in texture, staining, width, and outline of its edge.

Moreover, in a few pseudopods, of a width corresponding to the diameter of the blood plates, one or more short lengths of the central, red, granular portion may be seen to be marked off by constrictions or to be definitely separated and to appear as rounded masses or segments of the same diameter and with the same appearances as the central portions of the blood plates (Figs. 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12 and 14). Such separate, rounded masses thus are completely surrounded by the hyaline material constituting the marginal zone of the pseudoped and the appearances are thus produced of a typical blood plate with its hyaline marginal portion continuous with the hyaline marginal portion of the pseudopod; or of a pseudopod formed out of a short chain of blood plates by the continuity of their marginal portions.

Furthermore, there may be observed short bud-like pseudopods springing, either directly from giant cells or from other pseudopods, with rounded, central, granular portions, either separate from, or continuous with, the central granular portion of the main mass of cytoplasm (Fig. 13). The smaller of these bud-like pseudopods are also in every respect like blood plates, except that they are obviously a part of the cytoplasm of a giant cell.

In brief, the two constituents of the cytoplasm of the pseudopods and of the bud-like processes of the giant cells are identical with the two substances making up the blood plates in staining reaction and texture and they are similar in their arrangement with reference to each other. Furthermore, all grades of transition exist between bud-like processes of giant cells in process of detachment (Fig. 13), or slender pseudopods showing signs of dividing into smaller parts by transverse division and the blood plates (Figs. 1, 2, 3, 4, 5, 7, 8, 10, 11, 12 and 14).

In view of these facts the inference seems to be justified that the blood plates are detached portions of the cytoplasm of the giant cells. This idea derives additional support from the following considerations:

1. That the giant cells do lose their cytoplasm. This is shown by the relatively small amount of cytoplasm of some of the giant cells exhibiting ameboid forms, and by the occurrence of degenerate looking-giant cell nuclei with little or no cytoplasm connected with them (Fig. 4.) The appearances seem to clearly indicate that this loss of cytoplasm occurs chiefly by the detachment of buds or plate-like fragments or segments from pseudopods, or of whole pseudopods, rather than by disintegration and liquefaction, evidence of which may be seen in some giant cells.

2. The number of giant cells and pseudopods in which the appearance of plate formation is present is only a small proportion of the whole number of giant cells and is not greater than could be expected at any given moment in view of the numbers of the blood plates.

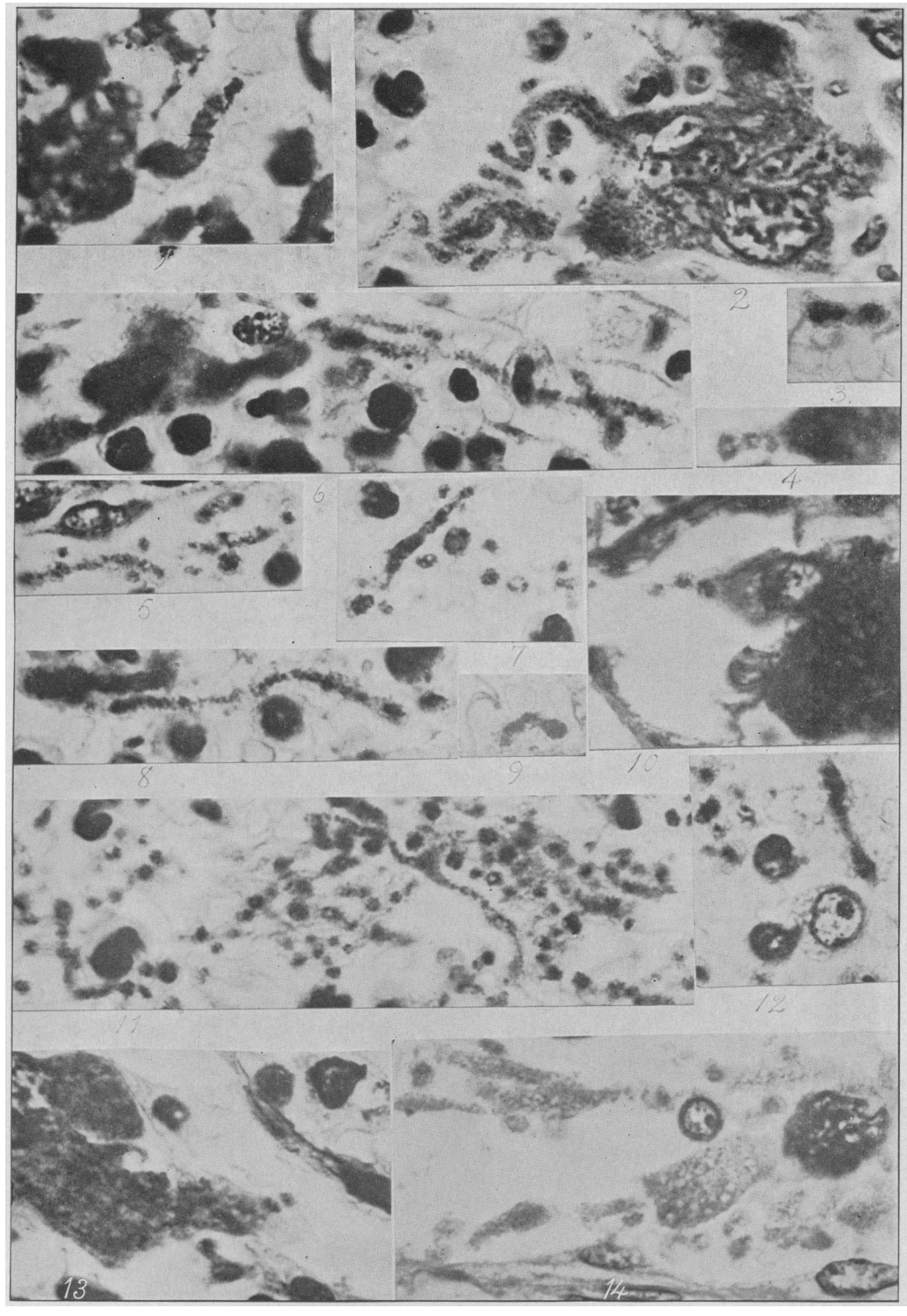
3. The direct observation by me of protoplasmic movements of identical character, both in the hyaline marginal zone of the giant cells and in the hyaline marginal zone of the blood plates on the warm stage of the microscope. These movements have been described by Detjeen and others for blood plates. I have seen the hyaline marginal zone of the giant cells and of the blood plates constantly changing its outline, sending out and withdrawing short processes of various shapes. The so-called ameboid movement of the blood plates is not surprising, because it is known that detached fragments of living protoplasm may exhibit independent movement.

In this connection I may state that I have seen a few giant cells change their form very markedly, sending out and withdrawing pseudopods, such as are seen in the sections. This seems to show that the presence of pseudopods and protoplasmic prolongations of giant cells and even of whole giant cells in blood vessels, as I have seen in the sections, is not a passive act, due to local conditions of pressure in the tissue, but is a manifestation of the vital activity of the giant cell.

4. According to my own and others' observations, bodies that are undoubtedly and obviously blood plates are found only in the blood of mammals, and mammals are the only creatures that have giant cells in the blood forming organs. I have found undoubted, characteristically staining blood plates in the blood of all of a considerable variety of mammals including the opossum and camel, and I have found giant cells in the blood forming organs in all mammals, including the opossum, in which I have sought for them. The so-called spindle cells or fusiform corpuscles of the birds, amphibia, reptiles and fishes have been claimed by some writers to be the morphological equivalents of blood plates, but my studies of the blood of these vertebrates have not led me to accept this view.

5. It would seem from my own observations and from the studies of others that the blood plates make their first appearance in embryonic mammalian blood at about that stage of development when the giant cells have first appeared in the blood forming organs. This point, however, is not as definitely established as I could wish.

6. A comparison of the results of the enumeration of blood plates, obtained by Helber and by Pratt in certain pathological conditions, with the histological findings in the bone marrow in the same diseases suggests a relationship between the blood plates and the giant cells. Thus in pernicious anemia and lymphatic leukemia the blood has been repeatedly found to contain abnormally few plates, while the marrow in typical cases of this disease, as far as can be inferred from the reports in medical literature and from my own observations, undergoes profound changes in the character of its cellular constituents with resulting very marked diminution in the number of the giant cells. On the other hand, in post-hemorrhagic anemia, the blood



Origin of the blood plates from the giant cells of the bone marrow.

plates are increased in number and there is also increase in the amount of red marrow with good evidence that the number of giant cells in the blood forming organs are relatively and absolutely increased in number.

In so-called myelogenous leukemia the blood plates are also increased in number, and in the cellular accumulations of this disease giant cells do not seem to be an uncommon finding, although but little attention has been paid to them by pathologists. In view of the enormous increase in the marrow elements in this disease it must be obvious that the presence among them of a relatively small proportion of giant cells means a great absolute increase in the number of such cells in the body.

My acknowledgments are due to Dr. Oscar Richardson, assistant pathologist, for relieving me of much of the regular work of the laboratory during the period in which I have carried on this study.

DESCRIPTION OF PLATE.

The photomicrographs were made by Mr. L. S. Brown in the Pathological Laboratory of the Massachusetts General Hospital from sections of the bone marrow, spleen and lung of the cat, the blood plates of which animal are especially large. The magnification in all the figures is approximately 1500 diameters.

Fig. 1. Giant cell with a pseudopod projecting into a small blood channel of the bone marrow. A blood plate in process of pinching off is seen at the free extremity of the pseudopod. The granular portion of the cytoplasm is densely stained. The hyaline margin of the pseudopod is only faintly shown.

Fig. 2. Giant cell with a pseudopod projecting into a blood channel of the bone marrow. Other pseudopods either free or attached to the cell are also shown. Two small rounded bodies near the pseudopods in the vessel are either blood plates or cross sections of pseudopods.

Fig. 3. Detached pseudopod in a capillary of the lung in process of segmentation into blood plates.

Fig. 4. A small pseudopod segmenting into plates and still attached to a nearly naked giant cell nucleus in a blood vessel of the spleen.

Fig. 5. Blood plates and detached pseudopods in a blood vessel in the spleen.

Fig. 6. A giant cell with pseudopods, two of which stretch far into a small blood channel of the marrow. The continuity of one of them is not visible in the figure.

Fig. 7. Blood plates and a detached pseudopod in process of segmenting into blood plates. The vacuole-like unstained areas in the central portions of the pseudopods and of the plates are shown. Two leucocytes are present.

Fig. 8. Detached pseudopods showing segmentation and transitions to blood plates. These lie in a small blood vessel of the marrow.

Fig. 9. Small detached pseudopod showing indications of segmentation in a lung capillary.

Fig. 10. Giant cell in the marrow with pseudopod protruding into a blood vessel through its thin wall. The free portion of the pseudopod has segmented so as to form a short chain of three blood plates connected together by their hyaline marginal portions.

Fig. 11. Thrombus-like mass of blood plates in a vessel of the marrow. Among the plates two detached pseudopods, one of which shows signs of beginning segmentation. Vacuole-like unstained areas are seen in some of the blood plates and in one of the pseudopods.

Fig. 12. A detached pseudopod, several blood plates, a few erythrocytes and three leucocytes in a blood vessel of the spleen. The hyaline marginal zone, both of the pseudopod and of some of the plates, is fairly well shown.

Fig. 13. A giant cell of the spleen with a pseudopod projecting into the lumen of a small blood vessel through its wall. At the free extremity of the pseudopod two plates are seen in process of formation.

Fig. 14. Giant cell in a blood vessel of the spleen with its cytoplasm nearly all arranged in pseudopods and more or less detached from the nucleus. Some blood plates are seen either free or in continuity with the pseudopods. Vacuole-like unstained areas are shown in the mass of cytoplasm at the left of the nucleus.

INFLAMMATION OF THE FRONTAL SINUS.*

BY HARRIS PEYTON MOSHER, M.D., BOSTON.

HEADACHE is a symptom which in a great many instances receives the most off-hand diagnosis as to its cause and the most off-hand treatment. The case is much like that of the crying baby and the soothing syrup. There is a sure remedy always at hand. It is on every dressing table and on the show case by every soda fountain. We are taught that cause and effect aways go together and so should be studied together. In the common symptom of headache, however, the effect often engrosses our attention to the exclusion of the cause. It is a truism, of course, but one which I shall take the liberty of repeating, that an eliminating diagnosis of the cause of recurring and chronic headache requires a most thorough, sustained and systematic physical examination plus a keen cross examination of the patient's personal and family history and a judicial weighing of the testimony thus secured. This means that the broad knowledge and sound good sense of the general practitioner must at times be supplemented by the examinations of the man doing special work, and it means that both should work together; and that the specialist in medicine like the specialist in finance should try to keep out of "fads and fancies."

The subject of this paper is acute and chronic inflammation of the frontal sinus. The chief symptom of disease of the frontal sinus is headache. I ask your permission to make what I have to say a little informal and in the line of a demon-

* Read before the Lawrence Medical Club, April 23, 1906.
Charts and specimens from the Anatomical Laboratory of the Harvard Medical School.