the plate covered with black paper. In the top of one of these tubes was placed a Nicol prism, while over the opening of the other was laid a piece of cardboard containing a hole of the same dimensions as the prism, in order that the area of the plate which was affected by the ordinary light would be of the same size as that struck by the polarized light. Also over the top of the tube through which the ordinary light was to pass was placed a "neutral wedge" and by means of this the intensity of the light which struck the plate under this tube was brought to the same value as that which impinged upon the plate under the Nicol prism since this latter absorbed an appreciable amount of the incident rays. These two intensities were measured by means of a Macbeth illuminometer. The source of light was a 150 watt bulb of the ordinary gas-filled type, and between it and the plate was placed a bottle through which running water was passing and which acted as a screen to remove the heat radiations from the light.

On a Petri dish which had been prepared in this manner it was possible to have the three conditions under which an experiment was to be carried out all on the same plate; the temperature was uniform over the surface of the plate, and side by side were the areas to be exposed to polarized light, ordinary light and the portions which were to be kept in the dark.

It was found in these latter experiments, as in the case of the former ones, that there was a marked increase in the brightness of that area which had been exposed to polarized light as compared with the rest of the plate. That this was due to an increased rate of growth was determined by the fact that the bacteria had utilized the medium throughout that section of the plate which had been affected by the polarized light, bringing about a diminution of the light over that area even before the other portions of the plate had reached their maximum intensity of luminescence. Inasmuch as there is no method of measuring the intensity of the light of growing bacteria, no quantitative results could be obtained in these experiments, but a conservative estimate of the time required for such a portion of the plate to reach its maximum intensity was one third that of the other parts, whether exposed to ordinary light of the same intensity as that of the polarized light or whether kept in the dark.

During the course of this work some eighteen experiments were performed, of which number fifteen gave positive results, the other three giving results which, while *not* negative, were not of a sufficiently positive nature to warrant them being grouped with the others.

The question arose: Was there any effect of the polarized light on the medium itself? In order to answer this, plates of medium were exposed for about eight hours to light which had passed through a Nicol prism and were then planted with bacteria. Control plates of agar were also made and sown at the same time, but no difference in luminescence could be noted between the two plates.

In view of the fact that there has been practically no work done on the processes which take place inside of a cell upon exposure to polarized light, the cause for this increased growth is a matter of conjecture. However, Miss Semmens's work, which has very recently appeared in a more detailed form,[3] points to an increased rate of the hydrolysis of the starches in the plant. Although there is no starch in the bacterial cell, there are undoubtedly other carbohydrates which may be acted upon in the same manner in which the plant starches are by some of the enzymes present in the cell.

I wish to thank Dr. E. N. Harvey, professor of physiology at Princeton University, for his kind suggestions and interest in this work.

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THE NON-NUCLEATED CELLULAR ELEMENTS OF THE BLOOD[1]

IN a comparative hematological survey probably no one feature is so striking as the contrast between mammals and all other vertebrates with reference to the occurrence of non-nucleated elements in the blood. In lower vertebrates the blood cells are all nucleated; ascending the phylogenetic scale to mammals, we find that by far the major bulk of the circulating cellular elements has been replaced by non-nucleated structures or plastids, as they may be conveniently designated. That the formation, function, quantitative regulation and fate of this predominant mass of non-nucleated material in both health and disease is of fundamental importance can not be questioned.

The history and present status of our conceptions as to the occurrence, nature and origin of these structures may be summarized as follows:

First: That in consequence of the apparently exclusive occurrence of these elements in the mammalian organism, a sharp line of demarkation or hematological discontinuity has been drawn between mammals and all other vertebrates. Indeed, in 1875 Gulliver classified vertebrates into two great groups—the pyrenaemata, in which it was stated that "the blood cells of every animal without any known exception were nucleated," and

[3] Baly, E. C. C., and Semmens, E. S. Proc. Roy. Soc. B, *97*, 250–253, 1924.

[1] Abstract of a paper presented in a symposium on the blood at the fortieth annual session of the American Association of Anatomists, Buffalo, N. Y., 1924.

the apyrenaemata or mammals having non-nucleated elements. Up to the present time, any reported occurrence of non-nucleated structures or plastids in the blood of vertebrates other than mammals has been met with skepticism and their appearance labeled as artifacts or pathological phenomena.

Second: Our interpretations as to the nature of these elements in mammals have diverged fundamentally in two directions: the one (a) accentuating the nucleated nature of all cytological units of the organism has adhered to the proposition that these elements are still nucleated cells which have merely undergone changes obscuring the demonstration of their nuclear components; the other (b) maintains the now dominant conception that these elements can not be correctly designated as other than non-nucleated structures.

Third: Granting their non-nucleated nature, two divergent views again arise as to the origin of these elements: the one (a) involving the detachment and liberation of cytoplasmic segments from the parent cell (as in the case of the blood platelets for example) and the other (b) involving a process of nuclear extrusion (as in the case of the erythrocyte).

In the further consideration of these questions, the present discussion will center around three stages in hematological evolution:

First: The primitive stage in which the cellular elements of the blood both phylogenetically and ontogenetically are at first all nucleated structures.

Second: An intermediate stage common to certain lower vertebrates and the early mammalian embryo in which all the original nucleated types of the preceding stage continue to occur in the circulating blood plus certain non-nucleated structures which are now beginning to appear.

Third: A stage attained only in the older embryonic and adult mammal in which the development of non-nucleated elements has acquired maximum expression and the corresponding parent nucleated cells have disappeared from the circulating blood.

The proposition that both phylogenetically in the lower vertebrates and ontogenetically in the early mammalian embryo, all the cellular elements of the blood are nucleated structures requires no discussion.

Turning then to the second stage in hematological evolution, a stage in which non-nucleated structures first begin to appear, let us direct attention first to the blood in amphibia, a vertebrate group in which respiratory and vascular adaptations have played such a critical rôle phylogenetically, in the transition from an aqueous to a terrestrial environment, and second to a comparison of these amphibian conditions with a corresponding stage in the mammalian embryo.

The cellular elements of the blood in amphibia are generally supposed to consist exclusively of non-nucleated elements. The following résumé of a series of comparative studies[2] show, however, a different state of affairs:

1. In five species of amphibia a type of plastid was demonstrated which consists of a central mass of azur-staining granules surrounded by a peripheral area of hyaline cytoplasm. These elements arise as cytoplasmic segments detached from nucleated cells or thrombocytes having a similar cytoplasmic structure. Since these plastids not only participate in coagulation processes but also appear identical in cytological structure with that of the corresponding elements in mammals, they may be justifiably designated as blood platelets or thromboplastids.

2. A second type of plastid was also found in these five amphibia which in contrast to the platelets consist of large basophilic staining granules and present no peripheral hyaline cytoplasmic area. It can be readily shown that these elements are mast cell derivatives and may consequently be correctly designated as basophilic plastids. Here again the plastids arise through a process of cytoplasmic segmentation from mast cells which may be found at various stages in the liberation of their cytoplasmic products.

The preceding data have been concerned with leucocytic elements. Let us now direct attention to the erythrocyte.

3. In five species of amphibia erythroplastids were found to the extent of from 1 to 5 per cent.

4. Batrachoseps attenuatus, B. pacificus and B. major are amphibians par excellence for erythroplastids, for here 95 to 98 per cent. of the erythrocytes may be non-nucleated. In all these amphibia, both nucleated and non-nucleated elements show great variation in size.

5. That these erythroplastids can not be discredited as degenerative products of little functional utility in an animal in which they may constitute 98 per cent. of the circulating erythrocytes is at once obvious. This is further confirmed by the presence of mitochondria and reticulation in both large and small erythroplastids.

6. That the occurrence of these amphibian erythroplastids is not to be associated with senility or possibly pathological conditions is demonstrated by the occurrence of these elements even in the larval animals.

[2] Emmel, V. E. 1914, "Concerning certain cytological characteristics of the erythroblasts in the pig embryo and the origin of non-nucleated erythrocytes by a process of cytoplasmic constriction." *Am. Jour. Anat.*, Vol. 16, pp. 127–194. 1920, "The erythrocytic and leucocytic elements in the blood of Batrachoseps attenuatus." *Anat. Rec.*, Vol. 18, p. 232. 1921, "Hematological and respiratory conditions in the larval stages of the lungless amphibians, Batrachoseps attenuatus and Anaides lugubris." *Anat. Rec.*, Vol. 21, p. 56. 1924, "The occurrence and genesis of non-nucleated erythrocytes or erythroplastids in vertebrates other than mammals." *Am. Jour. Anat.*, Vol. 33, pp. 347–405. 1924, "Leucoplastids or non-nucleated leucocytic derivatives in vertebrates other than mammals." (In press, *Am. Jour. Anat.*)

7. Finally that neither the leucocytic or erythrocytic plastids can be relegated to the category of artifacts is evidenced by the fact that platelets, basophilic plastids and erythroplastids can be demonstrated in blood vessels carefully fixed *in toto*.

8. Turning now to the question of the origin of these erythroplastids, it can be shown that they arise as segments of hemoglobin containing cytoplasm constricted off from the parent cell. The detached plastids are of variable size, thus accounting in part at least for the variations found in the non-nucleated products. Nucleated remainders are in evidence possessing a variable rim of cytoplasm left after the formation of the plastids.

9. No evidence of either nuclear extrusion or intracellular disintegration of the nucleus in the origin of these elements was obtained. If erythroplastids owe their origin to any cytological mechanism of this nature, positive proof ought certainly to be forthcoming in the large cells of amphibia where such elements have first begun to make their appearance, but the evidence here is entirely negative.

So far in the consideration of this second stage in hematological evolution we have been dealing with conditions in lower vertebrates. Let us now turn to corresponding stages in the mammalian embryo.

10. *In toto* mounts of fixed blood vessels of the pig embryo at a period in which the transition from nucleated to non-nucleated elements is making its appearance, it can be shown that here again the erythroplastids arise as cytoplasmic segments detached from the nucleated cell. Just as in amphibia here also the erythroplastids show great variation in size and the nucleated remainders possess a variable rim of cytoplasm.

11. This evidence from fixed embryonic blood vessels is confirmed by a series of consecutive observations on tissue culture preparations of living nucleated erythrocytes in which the mature erythroblasts were seen to undergo a process of cytoplasmic subdivision resulting in the formation of typical non-nucleated erythrocytes.[3]

12. Consequently, it will be observed that point for point the genesis of erythroplastids in amphibia and mammalian embryo coincide to a remarkable degree. The fact that in its most complete expression the process of erythroplastid formation in the adult mammal may involve a reduction in the cytoplasm associated with the nucleated remainder to such a small minimum as to closely simulate the extrusion of a naked nucleus, appears largely responsible for the prominence which the conception of nuclear extrusion has come to occupy in our hematological literature. It is only upon acquaintance with the behavior of the large erythrocytic cells of the mammalian embryo and of the amphibian that the fundamental nature of the process becomes most clearly evident.

The third stage in hematological evolution has been attained only in the late embryonic and adult mammalian organism. Here, as is well known, erythroplastids and blood platelets, both quantitatively and numerically, dominate. In contrast to the preceding stages, the parent nucleated progenitors of these elements are no longer present; they have now disappeared from the blood stream and become localized in regions obviously more favorable for their proliferation and the elaboration of their specific products. From these local regions through the agency of segments of cytoplasm liberated into the blood stream they continue their original functional rôle in the circulating blood.

It is not without interest here to also note that there is cumulative data in the more recent investigations indicating that lymphocytes and possibly even mast cells also evidence a tendency through cytoplasmic segmentation to give rise to corresponding plastids in the connective tissue spaces and lymphatic channels, but that these plastids do not persist and appear to go into solution before or upon entering the systemic circulation.

In résumé the objectives of the present paper have been:

First: To stress the fact of the occurrence of non-nucleated elements in the blood of vertebrates other than mammals.

Second: To show that a sharp hematological discontinuity between mammals and other vertebrates in this respect is consequently no longer tenable.

Third: To emphasize the origin of these elements as segments of cytoplasm detached from leucocytic and erythrocytic cells.

Fourth: That this process of cytoplasmic segmentation furnishes a mechanism of fundamental significance in an adaptation whereby in the course of hematological evolution from the lower vertebrates to mammals, nucleated blood cells may become localized in extra vascular regions and still maintain their original functional rôle through the agency of segments of cytoplasm liberated into the circulating blood.

The conception that segments of cytoplasm may become detached from nucleated cells and persist as intact definitive non-nucleated elements in the circulating blood has been slow to find recognition. The fundamental tenet that the unit of living matter is the nucleated cell is naturally conducive to conservatism in the recognition of such a process. In spite of the overwhelming evidence, for example, of the megakaryocytic origin of blood platelets, we still find a persistent reiteration of the view that these elements are independent living structures without derivation from any known blood cells. Indeed Perroncito[4] has recently voiced an apparent undercurrent in this opposition with the statement that "it is superfluous to say that the theoretical importance of this teaching goes beyond any hematological research and the

[3] Emmel, '14, *loc. cit.*

[4] Perroncito, A., 1920, "On the origin of platelets from megakaryocytes," Hematalogia, Vol. 1, p. 111.

question of the origin of platelets; it faces our fundamental modern conceptions of the problems of life. We do not find, as far as I know, in all our knowledge of biology a phenomenon which may be compared to the derivation of platelets from megakaryocytes. In all the history of the human body, we do not find any cellular elements from which parts of protoplasm detach themselves and form another category of elements with a deeply different, well-defined, morphological individuality as in the case of platelets and megakaryocytes."

Obviously a question of this character must eventually be settled by facts rather than by preconceived ideas or opinions. On the basis of the data just elaborated, we appear obliged to recognize the necessity of a modification of our previous conceptions of the nature and origin of the non-nucleated elements of the blood.

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THE ILLINOIS STATE ACADEMY OF SCIENCE

THE eighteenth annual meeting, held at Springfield, Illinois, February 20 and 21, 1925, was one of the best in the history of the academy. It was well attended, both by members and by citizens of Springfield, and the many and varied papers were much appreciated.

On Friday, February 20, there were three general sessions and two business meetings, and Saturday forenoon the following section meetings were held: biology and agriculture, chemistry and physics, geography and geology, medicine and public health, psychology and education, and a high school section. There were eighty-three papers given in the two-day program.

Saturday noon the academy joined the Mid-Day Club of Springfield for luncheon, at the close of which President Burton, of the University of Chicago, gave an interesting address on "The place of research in modern life." Trips were planned for Saturday afternoon by the local committee to points of interest about Springfield, among them being visits to a coal mine, to Lincoln's Tomb, and to the following laboratories: The State Department of Health, the State Highway Department and St. John's Hospital.

The following officers were elected for the coming year:

President: Dr. Stuart Weller, University of Chicago.

First Vice-president: Mrs. Eleanor C. Smith, Englewood High School, Chicago.

Secretary: Professor C. Frank Phipps, State Teachers College, DeKalb.

Treasurer: Dr. W. B. McDougall, University of Illinois.

Librarian: Dr. A. R. Crook, Chief, State Museum, Springfield.

The academy now has 551 members, and there are affiliated with it thirteen independent scientific societies of the state and several high school science clubs.

C. FRANK PHIPPS
Secretary

DEKALB, ILLINOIS

THE OKLAHOMA ACADEMY OF SCIENCE

THE thirteenth annual meeting of the Oklahoma Academy of Science was held in Norman at the University of Oklahoma on February 14, 1925, under the presidency of C. E. Sanborn, of Stillwater. The academy met in three sections. The following papers were presented:

BIOLOGY SECTION

The effect of secretin on the secretion of the pancreas, kidney and submaxillary glands: ALMA J. NEILL and LESTER L. FRITZ.

The effect of thyroparathyroidectomy on body activities: HOMER L. BRYANT.

The action of lobelin upon the circulatory organs: GERTRUDE NEILSEN.

Adaptions in caudal musculature: RUTH HOLZAPFEL.

Definitive sex cells of the chick: HAROLD HULPIEU.

Further notes on the oviposition for Bruchus, and the orientation of the embryo in the egg during development: ALFRED BRAUER.

A dipterous parasite of the tomato worm moth—Protoparce quinquemaculatus: HAROLD M. HEFLEY, Jr.

A Cylindrotaenia from Bufo woodhousii: VAN A. JOSEPH.

Notes on the reptiles and amphibians of Okmulgee County, Oklahoma: EDITH R. FORCE.

Preliminary list of snakes of Oklahoma: A. I. ORTENBURGER.

Ecological succession in the Arbuckle region: A. F. SHULTZ.

Distribution of spiders as correlated with environmental factors: VERA G. SMITH and D. YOUNG.

The biome as an ecological unit: A. O. WEESE.

Oklahoma climagraphs and biotic regions: A. O. WEESE.

The supertidal animal community in the Puget Sound Region: A. O. WEESE.

The genetic factors of growth with especial reference to Cucurbit's crosses: ORVILLE C. SHULTZ.

Linkage relations: W. A. CRAFT.

Notes on the Oklahoma species of Onthophagus: W. J. BROWN.

Evidence of increase in certain rare species of birds in Oklahoma: R. O. WHITENTON.

Some materials used in nest construction by certain birds of the Oklahoma panhandle: R. C. TATE.