THE ARNETH COUNT, WITH PARTICULAR REFERENCE TO ITS DIAGNOSTIC VALUE IN ASTHMA

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The Arneth count.—The neutrophilic polymorphonuclear leucocyte develops from a mononuclear cell (myelocyte) with a single round nucleus. The myelocyte passes through an intermediate stage with a single indented nucleus (metamyelocyte), but with no true nuclear lobulation. It is evident, therefore, that the cell with a simple round nucleus is younger than that with an indented nucleus and this form is younger than the true polymorphonuclear cell. Arneth (1904) argued from this line of thought by contending that a polymorphonuclear cell with only one lobe was younger than one with two lobes and so on. He studied blood smears from many different cases of acute and chronic infections and stated that very important morphological changes were found in the nuclei of polymorphonuclear neutrophilic leucocytes. He divided these cells into five classes, the division being based on the shape of the nuclear material :—

Class I containing cells with one round or indented nucleus.

Class II containing cells with two nuclear divisions.

Class III containing cells with three nuclear divisions.

Class IV containing cells with four nuclear divisions.

Class V containing cells with five or more nuclear divisions.

Each class has subdivisions according to the shape of the nuclear portion, whether round or s-shaped, making twenty-five types in all. Arneth counted one hundred polymorphonuclear cells and arranged them in his five classes like this :

I	II	III	IV	V
5	35	41	17	2

This expression is known as the Arneth count. Arneth stated that the percentage of cells in the various classes varied only within normal limits in health, but changed in infectious conditions, the change usually being in the direction of an increase in the percentage of classes I and II and a decrease in classes III, IV and V; this he spoke of technically as a 'shift to the left'. Particular emphasis was laid on the prognostic value of this classification in pulmonary tuberculosis. Arneth's classification did not define when a nucleus might be considered as divided and so allowed the personal factor to assert itself unduly. To rectify this Cooke (1914) has given a criterion of nuclear lobulation—'If there is any band of nuclear tissue except a chromatin filament connecting the different parts of a nucleus, the nucleus cannot for the purpose of the Arneth count be said to be divided'; when the count is made according to Cooke's method the average normal figures vary considerably from those obtained with Arneth's method. Cooke (1914 and 1928) gives the following figures as the average normal :

I	II	III	IV	V
10	25	47	16	2

Schilling (1920) simplified Arneth's classification by dividing the neutrophilic cells into the following four groups.

Group I myelocytes.
Group II young metamyelocytes (with only the slightest indentation) of the nucleus.
Group III older metamyelocytes (with deep indentation but no true lobulation of the nucleus).
Group IV polymorphonuclears.

In doing the ordinary differential count of leucocytes, each of these types is counted separately, so that in the result each variety of neutrophilic granular cells is expressed as a percentage of the total number of leucocytes; in Arneth's method they are expressed only as a percentage of the total neutrophilic cells. As a normal figure Schilling gives neutrophilic granular cells 67 per cent—these are composed of 63 per cent polymorphonuclear and 4 per cent of old metamyelocytes (band forms). The young metamyelocytes and myelocytes are absent from the normal blood.

Pons and Krumbhaar (1924) have proposed a further simplification in the Arneth count. They believe that essential clinical purpose is served if all neutrophiles are subdivided into three groups as under

(1) Metamyelocytes (very young) with round or slightly indented nuclei.
(2) Non-segmented forms (young) where the nuclear material is connected with broad bands.
(3) Segmented forms (older) where two or more groups of nuclear material are connected by narrow strands of filaments.

Roberts (1927) has recently proposed a still further simplification of the Arneth's classification in which the polymorphonuclear neutrophiles are divided into only two groups 'lobulated' and 'non-lobulated'. Roberts states the number of non-lobular forms to be 25 per cent. A non-lobular count of 35 per cent or over (except during menstruation when a normal count may rise up to 35 per cent) is indicative of an acute inflammatory process.

The Arneth index.—In Arneth's count the result is expressed in five sets of figures which is rather cumbersome and it was desirable to replace such an expression by a single figure. Many ways of doing this have been suggested.

(1) Arneth took the sum of the cells in the first two groups as the index.

(2) Bushnell and Treuholtz (1908) proposed the sum of the cells in group I and group II and one half of

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(*Continued from previous page*)

Smith, E. C., and Elmes, B. G. T. (1928). Creeping Eruption in Lagos. *Trans. Roy. Soc. Trop. Med. and Hyg.*, Vol. XXII, p. 289.
*van Harlingen, A. (1902). Report of Three Cases of Creeping Larvæ in the Human Skin (Hyponomoderma, Kaposi). *Amer. Journ. Sci.*, Vol. CXXIV, p. 436.
White, G. F., and Dove, W. E. (1928). The Causation of Creeping Eruption. *Journ. Amer. Med. Assoc.*, Vol. XC, p. 1701.

* Original papers not available.

the cells of group III. This index is commonly used as the Arneth index.

(3) Ponder and Flinn (1926) suggested the following: The cells of each group are multiplied by the number of the group (group I by 1, group II by 2, and so on), the results added, and the total divided by the number of cells counted. The average normal index thus computed is 2.7.

(4) Hamilton-Black's (1913) index is obtained by multiplying the number of cells in class I by 10, the number of cells in class II by 18, the number in class III by 22, and the number in class IV by 25, 100 cells being dealt with altogether. Normally it is about 2,000 and cannot be less than 1,000. It is based on a finding that the phagocytic activity of the cells of various classes are as 10 : 18 : 22 : 25. The use of this index implies the acceptance of these figures for phagocytic ratios, but Ponder and Flinn (1926) were unable to find any significant difference between the phagocytic activity of the various Arneth classes of the polymorphonuclear cells. Ponder (1928) concluded that, so far as diapedesis and phagocytosis *in vitro* were concerned, the cells of various Arneth classes were indistinguishable, for the increase in the nuclear lobulation which occurred with the increasing age of the cell did not apparently enable the cell to pass more readily from the vessels and lymph spaces into infective cavities, nor did it render more active as a phagocyte.

The experimental confirmation of Arneth's theory regarding the age of the polymorphonuclear leucocyte and conformation of the nucleus.—Colbert (1924) using vital stains confirmed Arneth's view of the significant relation between the shape of the nucleus and the age of the cell. In the films he identified several neutrophiles with unsegmented nuclei and repeatedly traced the outline of an individual nucleus for three hours. In no instance did any nucleus, once identified as an unsegmented type, became segmented under observation. He is of the opinion that the constant shape of the neutrophile nucleus in the living state for several hours supports the view that the shape of the nucleus was not an accident but bore a definite relation to life history of the cells.

The study of the effect on the Arneth count of substances which stimulate the bone marrow to rapid and increased production of leucocytes provides evidence in favour of Arneth's assumption that the cell with a one-lobed nucleus is younger than that with two, and so on. Lim, Sarkar and Brown (1922) had shown that thyroid substance definitely stimulated the bone marrow in rabbits and this substance has been used by Ponder and Charipper to study the effect on the Arneth count when bone marrow was stimulated. Ponder (1924 and 1926) found that in rabbits repeated injections of thyroid resulted in markedly increasing the percentage number of polymorphonuclears with a simple (immature) nucleus which he thought was due to thyroid stimulating the bone marrow, resulting in the increased production of an immature type of cell. A single injection of thyroid produced a deflection of the Arneth count, a large number of cells of class I being introduced into the circulation; subsequent changes in the count were followed and it was shown that the cells of class I developed in the blood stream into cells of class II, these into cells of class III and so on until class V was reached. Charipper (1929) showed the same effect of thyroid on the Arneth count of a perennibranchiate amphibian.

Another substance definitely known to effect the bone marrow is benzol. Weiskotten and others (1915, 1919 and 1924) have shown that subcutaneous injections in rabbits of an olive-oil and benzol mixture first caused a rapid decrease of leucocytes in the peripheral circulation after which a primary rise occurs, this is followed by a secondary fall and a secondary rise. They noted that the phenomenon was accompanied by a marked aplasia of the bone marrow following the injection with active regeneration occurring at the time of secondary rise. Hunt and Weiskotten (1930) thought that experimental verification of the interpretation of Arneth's classification would be possible in the conditions brought about by benzol injection. A marked leucopenia was followed by a large number of polymorphonuclear leucocytes being produced rapidly and passed into circulating blood, so that leucocytes known to be in varying stages of life cycles could be studied. From his study he concluded that cells with single-lobed nuclei were young or immature forms, and that the number of lobes increased with the maturity of the cells. According to Cooke the length of life of a polymorphonuclear cell in circulation is about three weeks.

The steady state of the Arneth count.—The constancy of Arneth count in normal and pathological conditions is very remarkable. Ponder (1926) maintains that this constancy was the result of a balance between at least three factors—the production of the polymorphonuclear cells, their removal, and their development from class to class. He came to the conclusion that the distribution among the various Arneth classes was due to the cells remaining a short time in class I, a longer time in class II, a still longer time in class III and so on, the cells normally entering the circulation as cells of class I and leaving it from classes IV and V. The steady state in abnormal conditions, he thought, was due to the cells leaving the circulation from classes earlier than classes IV and V.

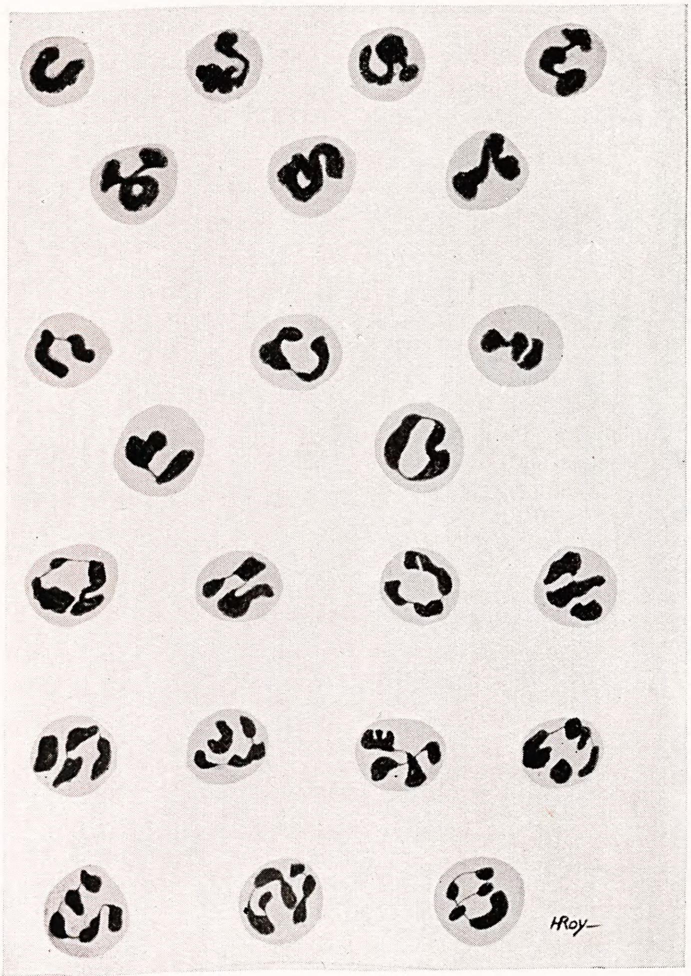
Influence of various drugs, organic and inorganic extracts, colloidal metals, ultra-violet and *x-ray* exposures on the Arneth count in experimental animals.

A shift to the left with thyroid and benzol has already been referred to. Ponder and Flint (1926) found that the removal of the thyroid in adult rabbits did not influence the Arneth count. They have shown that gelatin, trypsin, colchicin, nucleic acid, ether and thyroxin all deflected the Arneth count in the rabbit to the left and that pilocarpine had no effect. Each one of these substances deflecting the count produced at the same time a polymorphonuclear leucocytosis and they concluded that the substances deflected the count by stimulating the bone marrow and thus causing an outpouring of the younger forms of the polymorphonuclears, which have simple nuclear configuration.

Kennedy and Grover (1928) found that by a single exposure to *x*-rays the Arneth count in rabbits was deflected to the left. Kennedy and Thompson (1928 and 1929) found a similar shift to the left by an exposure to ultra-violet rays and by injections of various gonad extracts and of pituitrin, adrenalin and insulin. Danzer (1930) found that extracts of various organs and tissues when injected into rabbits deflected the Arneth count to the left, the deflection being due to the contained protein. The destruction and absorption of tissues *in vivo* was followed by a similar deflection. He thought that the deflection in the Arneth count after injury to various tissues might possibly be explained by that observation. He further suggested that the continual and normal break-down of tissue in the body was sufficient to provide a stimulus for the continual and normal output of polymorphonuclears by the bone marrow. Climenko (1930 and 1932) found that administration of irradiated ergosterol deviated the Arneth count to the left in the same way as an exposure to ultra-violet rays. He found that small doses of colloidal preparations of iron, cobalt, tin, copper, strontium, and nickel produced no significant deflection in the Arneth count. When these substances were given in doses from two to eight times greater than the minimum dose they produce a marked left-handed shift. Intramuscular injections of colloidal calcium and intravenous injections of calcium chloride also caused the count to be deflected to the left. He suggested that the effect of these substances was a non-specific one, due to a deviation in the normal concentrations of the inorganic constituents of the blood serum.

Clinical significance of the Arneth count.—The narrow limits within which the count varies in health has been alluded to. Most pathologic conditions which produce any change cause a shift to the left, that is, a

PLATE VII



I.

II.

III.

IV.

V.

Some of the nuclear formations met with in the cells
in various Arneth classes

high index. Cooke (1928) states that in all cases of microbic infection there is an increase in the percentage of the younger cells of classes 1 and 2, and a diminution in classes 3, 4 and 5. According to Cooke an increase in the cells of classes 1 and 2 above 40 indicates toxæmia.

That the Arneth count is deflected to the left in various forms of tuberculosis in man is well known. Ponder and Flint (1928) found that in experimental tuberculosis in the rabbit there was a left-handed deflection of the Arneth count, as in the disease in man. The deflection to the left is so constant in tuberculosis that some observers have come to the conclusion that the appearance of the deflection is diagnostic of the disease. Arneth for example believed that this left-handed deflection occurred only in tuberculosis of active nature and in such cases alone, and when it occurred in other infections he thought that those infections were to be regarded as superimposed on a tuberculous basis; but Cooke (1914) showed that this view had no foundation and that the Arneth count could be deflected in a condition which had no tuberculous basis. He emphasized the occurrence of a left-handed shift as a constant occurrence in tuberculosis, but insisted that it was not characteristic of the disease alone. In tuberculosis the Arneth count was thought to be of great prognostic value, the higher the index the worse was the outlook thought to be. Arneth assumed that the cells with 1 and 2 nuclei were less resistant than the cells with 3, 4 and 5 nuclei and that when those less resistant cells were present in large numbers the severity of the case varied directly as the number of these cells. Hamilton-Black (1913) found that the phagocytic value against tubercle bacilli of the cells with 1, 2 and 3 and 4 nuclei was as 10 : 18 : 22 : 25. He observed that in certain cases of tuberculous disease tuberculin treatment improved the Arneth count making the shift to the left less marked. Holroyd (1913) studied the Arneth count in thirty cases of tuberculosis and arrived at the conclusion that in cases with unfavourable aspects the cells with one or with two nuclei were present in greater numbers than normally and that as the improvement in general condition took place the drift to the left of the picture was not so marked. Kennedy and Flint (1930) found that the Arneth count in cases of surgical tuberculosis treated by natural heliotherapy in the Alps did not show so great a left-handed deviation as in similar cases treated in Britain. They suggested that the fact might be taken as one of the indications of success of that method of treatment. This prognostic value of the Arneth count in tuberculosis has been very much disputed. As already mentioned, Ponder and Flint (1926) and Ponder (1928) could not confirm the findings of Hamilton-Black regarding the relation between phagocytosis and formation of the nucleus. They found that increase in nuclear lobulation which took place with increase of the age did not render the cell more active as a phagocyte.

A low index, *i.e.*, a shift to the right occurs in pernicious anæmia. Fleming (1929) quoted a case of pernicious anæmia on treatment with liver extract, which showed an abolition of the marked shift to the right in the count, as the total blood picture returned to normal. When the liver treatment was stopped the polynuclear count moved over to the right and was again restored to normal by the liver treatment.

Egroff (1926) draws the following conclusions from his investigation on a shift to the right in the Arneth count.

(1) A shift to the right is observed in about 20 per cent of healthy persons and is a constant and stable characteristic for certain groups.

(2) In many sick persons a shift to the right is a constant phenomenon which may be indicative of certain diseases or functional conditions, perhaps an expression of diminished ability to react.

(3) This form of shift is apt to be encountered more often in stubborn and chronic processes.

(4) Under solar or serum therapy the tendency is to convert the shift to the right toward a shift to the left in connection with clinical improvement.

(5) In patients normally presenting a shift to the right, an active process is not always accompanied by a shift to the left.

The technique.—For the Arneth count scrupulously clean slides and thin well-stained films are essential. The slides should be put in sulphuric acid overnight and washed well in running water for four hours or longer to remove all traces of the acid. They are next washed in distilled water and then in alcohol and stored in absolute alcohol. At the time of using the slide is thoroughly dried with a piece of clean linen.

Leishman's and Jenner's stains are not satisfactory for the nuclei are poorly stained and the granules of the cytoplasm are too prominent. Giemsa or Wright's stains are quite satisfactory, but the stain which is strongly recommended and which we have found very satisfactory is hæmatoxylin and eosin—this stains the nuclear structure very clearly whilst the neutrophilic granules are not stained. The smear is fixed in methyl alcohol and stained with Delafield's hæmatoxylin solution for 3 to 5 minutes. The slide is washed well in water and as a counter-stain a 0.5 per cent solution of eosin is applied for a minute or so. The slide is again washed, dried and examined. In counting the number of nuclei in each cell Cooke's criterion should be kept in mind and the nuclear parts joined by more than a thread should be considered as one (*see* plate VII). Some experience is required in making the count because sometimes the lobes are lying in such a way that, although they may be separate, the whole looks like one convoluted lobe.

The normals.—Arneth gives the following figures as a normal count :

I	II	III	IV	V
5	35	41	17	2

If Cooke's criterion is adopted the normal reads as follows :

I	II	III	IV	V
10	25	47	16	2

The normal Arneth index (Bushnell and Treuholtz index) is about 60. In our work in asthma which we report below we have always made the count according to Cooke's method and have used the Bushnell and Treuholtz index (*see* page 257).

The value of the Arneth count in asthma

Not much attention has been paid to the Arneth count in asthmatic cases. Bray (1931) states that many observers during the crisis have recorded a change to the left in the Arneth count (Schiff noted this in thirteen out of fifteen cases) but he was not able to confirm this finding.

We have done the Arneth count in 143 cases of asthma, the results are tabulated in table I and graph I. It will be seen that the index varies from below 60 to above 90 in different cases, the index being 60 and below in 7 cases, between 61 and 65 in 11 cases, between 66 and 70 in 20 cases, between 71 and 75 in 40 cases, between 76 and 80 in 21 cases, between 81 and 85 in 19 cases, between 86 and 90 in 17 cases, and above 90 in 8 cases. Taken as a whole these figures give no information of any value. When the cases are divided into the three groups suggested by us (the bronchial group, the Gram-negative-bacilli group, and the allergic group) we find that the Arneth index is usually high in the bronchial and Gram-negative-bacilli groups and usually low in the allergic group. If we take 70 as the dividing line we see that out of 79 bronchial cases 70 have an index above 70, out of 27 Gram-negative cases 19 have an index above 70, and out of 37 allergic cases 21 have an index below 70, and only 16 above 70.

If the allergic group be further divided into true allergic cases and mixed bronchial and allergic cases (table II and graph II) we see that out of the sixteen cases in this group with an index of above 70, 14 cases belonged to the mixed bronchial and allergic type and only two cases to true allergic type. These two allergic cases had an index of 71, so that for practical purposes all the true allergic cases have an index below 70. If the 19 mixed cases (bronchial *plus* allergic) be taken out of the allergic group and counted with the bronchial group we find that out of 98 cases only 14 have an index of below 70 and 84 cases have an index above 70. Of the 18 true allergic cases only two cases had an index above 70 (71). This

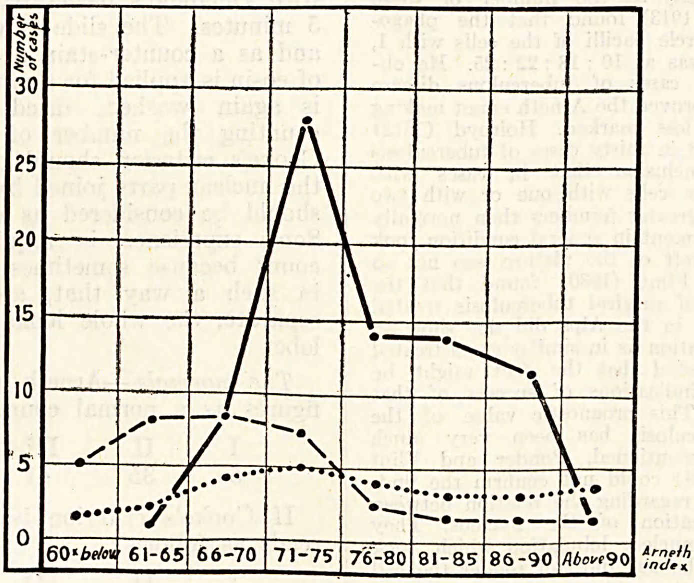
TABLE I

The Arneth indices in the three groups of asthma cases

Group	Total number of cases	Arneth index 60 and below	61-65	66-70	71-75	76-80	81-85	86-90	Above 90
Bronchial	79		1	8	28	14	14	12	2
Gram-negative-bacilli group.	27	2	2	4	5	4	3	3	4
Allergic	37	5	8	8	7	3	2	2	2
TOTAL	143	7	11	20	40	21	19	17	8

GRAPH I

The Arneth indices in the three groups of asthma cases



Bronchial cases 79
Gram-negative-bacilli cases .. 27
Allergic *plus* bronchial and allergic cases 37

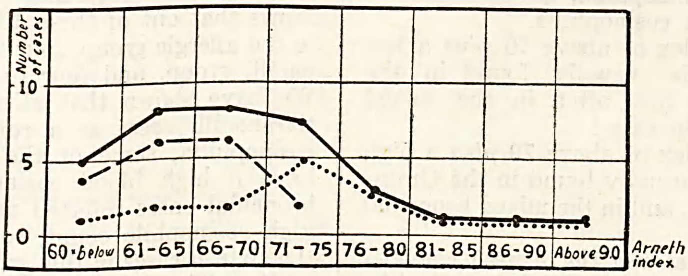
Table II

The Arneth indices in the allergic group of asthma cases

Group	Total number of cases	Arneth index 60 and below	61–65	66–70	71–75	76–80	81–85	86–90	Above 90
True allergies ..	18	4	6	6	2	..	..	..	..
Mixed bronchial and allergic cases.	19	1	2	2	5	3	2	2	2
Total	37	5	8	8	7	3	2	2	2

Graph II

The Arneth indices in the allergic group of asthma cases



Total allergic cases 37
True allergic cases 18
Mixed allergic and bronchial cases .. 19

is shown in table III. If the bronchial, the Gram-negative-bacilli, and the mixed bronchial

Table III

Group	Total number of cases	Arneth index 60 and below	61–65	66–70	71–75	76–80	81–85	86–90	Above 90
Bronchial + mixed bronchial + allergic.	98	1	3	10	33	17	16	14	4
Gram-negative-bacilli	27	2	2	4	5	4	3	3	4
True allergic ..	18	4	6	6	2	..	..	..	..

and allergic cases be grouped together (table IV) we find that out of 125 cases only 22 cases have an index below 70 while 103 have an index above 70. By looking at table IV we can say that the asthma cases can be provisionally divided into two classes by means of the Arneth count—one class containing allergic cases in which the Arneth index will be 70 or below, and the other class of bacterial cases containing the bronchial, the mixed bronchial and allergic, and the Gram-negative-bacilli cases in which the Arneth index will usually be above 70. This latter class can be broken up into its component groups by means of the blood eosinophile count; we have shown in a paper which will shortly be published that the bronchial cases usually have a low eosinophile count; whilst the mixed bronchial and allergic

Table IV

Group	Total number of cases	Arneth index 60 and below	61–65	66–70	71–75	76–80	81–85	86–90	Above 90
Bronchial, mixed and Gram-negative-bacilli cases.	125	3	5	14	38	21	19	17	8
True allergic cases ..	18	4	6	6	2	..	..	..	..

cases, the Gram-negative-bacilli cases and the allergic cases usually have a high eosinophile count. So that in summarizing we can state that :—

(1) The allergic cases usually have a low Arneth index and a high eosinophile count.

(2) The mixed bronchial and allergic cases with the Gram-negative-bacilli cases have often a high Arneth index and a high eosinophile count. The Gram-negative-bacilli cases can be separated from the mixed allergic cases by the presence of the Gram-negative-bacilli in the sputum.

(3) The bronchial cases usually show a high Arneth index and a low eosinophilia.

Conversely :—

(1) An Arneth index of below 70 is found in the allergic cases; this is usually associated with a high blood eosinophilia, but occasionally there is a low blood eosinophilia.

(2) An Arneth index of above 70 *plus* a low blood eosinophilia is usually found in the bronchial cases and not often in the mixed bronchial and allergic cases.

(3) An Arneth index of above 70 *plus* a high blood eosinophilia is usually found in the Gram-negative-bacilli cases, and in the mixed bronchial and allergic cases.

The total leucocytes and the Arneth count.—Tables V and V*a* show the relation between the total leucocyte count and the Arneth count. Table VI shows the relation between the total polymorphonuclear count and the Arneth count.

There are two groups of cases placed within heavy lines in table V that require some further explanation.

The first group consists of 16 cases with a leucocyte count of 13,000 to 37,000 per cubic millimetre showing no appreciable shift to the left. In other words in these cases a high leucocytosis is associated with a more or less normal Arneth count.

The second group consists of 31 cases with a leucocyte count of below 8,000 per cubic millimetre, with the Arneth count showing an appreciable or a very marked left-handed shift. In other words in these cases a leucopenia is associated with a marked shift to the left.

(1) *A high leucocytosis without any appreciable shift in the Arneth count.*—Table V shows that in all there were 45 cases with a leucocyte count of above 13,000 leucocytes per cubic millimetre of the blood. Out of these 45 cases there were 16 which had an Arneth index of below 70. Reference to table V*a* (p. 264) shows that out of these 16 cases eight belonged to the allergic group, four to the Gram-negative-bacilli group, and four to the bronchial group. We have shown that allergic and Gram-negative-bacilli cases as a rule have a high blood eosinophilia, some of the bronchial cases also have a high blood eosinophilia and the four bronchial cases referred to happened to have a high eosinophile count, so that we see that all the sixteen cases in this group had a high eosinophilia. The high leucocytosis in these cases is due to an increase in the numbers of eosinophiles, the number of polymorphonuclears remaining the same. We have plotted the total polymorphonuclears against the Arneth index in table VI. If we take the normal number of polymorphonuclears to be roughly 70 per

TABLE V

Arneth index

Total leucocytes under	60 and below	61–65	66–70	71–75	76–80	81–85	86–90	Above 90	
5,000	1	..	..	..	1	2	..	1	5
6,000	..	1	..	2	1	2	1	..	7
7,000	..	..	4	5	..	2	2	..	13
8,000	..	2	..	3	4	1	1	3	14
9,000	1	..	2	5	1	1	3	1	14
10,000	..	2	4	4	5	2	..	1	18
11,000	..	..	..	3	3	..	..	..	6
12,000	3	..	2	7	3	2	2	..	19
13,000	..	..	..	1	..	1	..	..	2
14,000	1	2	..	2	..	1	2	..	8
15,000	..	1	1	2	1	1	1	..	7
16,000	..	1	2	3	1	1	4	..	12
17,000	..	1	1	..	..	..	..	1	3
18,000	..	..	2	..	..	..	..	..	2
20,000	1	..	..	2	..	..	..	..	3
23,000	..	..	1	..	1	1	1	..	4
25,000	..	..	1	..	..	1	..	1	3
26,000	..	..	..	1	..	..	..	..	1
36,000	..	..	..	..	..	1	..	..	1
37,000	..	1	..	..	..	..	..	..	1
	7	11	20	40	21	19	17	8	=143

cent of the total leucocytes then a count of 13,000 leucocytes will roughly contain 9,000 polymorphonuclears. In table VI we find that sixty-nine, out of these 69 cases as many as forty-five had an Arneth index varying from 71 to 90, *i.e.*, showing a marked shift to the left.

TABLE VI

Arneth index

Total polymorphs under	60 and below	61–65	66–70	71–75	76–80	81–85	86–90	Above 90	
2,000	..	..	..	3	1	1	1	..	6
3,000	2	4	1	1	2	3	3	..	16
4,000	1	4	3	8	2	1	2	2	23
5,000	2	1	4	7	4	1	3	2	24
6,000	..	..	2	3	1	4	1	2	13
7,000	1	1	2	5	4	2	4	1	20
8,000	..	..	3	3	3	1	..	..	10
9,000	1	1	1	4	2	2	2	1	14
10,000	..	..	1	1	1	1	1	..	5
11,000	..	..	2	2	..	1	..	..	5
12,000	..	..	..	1	..	..	..	..	1
13,000	..	..	1	1	..	..	..	..	2
14,000	..	..	..	1	..	..	..	..	1
17,000	..	..	..	..	..	1	..	..	1
19,000	..	..	..	..	1	..	..	..	1
20,000	..	..	..	..	..	1	..	..	1
	7	11	20	40	21	19	17	8	= 143

there are 17 cases with a polymorphonuclear count of above 9,000 and that out of these cases there are only four with an Arneth index between 66 and 70, and the remaining 13 cases have an index varying from 71 to 90. This proves that a high leucocytosis combined with a low Arneth index means that the leucocyte increase is due to an eosinophilia.

(2) *The association of leucopenia with a high Arneth index, i.e., a marked shift in the Arneth count to the left.*—Table V shows that there were thirty-nine cases of this group who had a total leucocyte count below 8,000 per cubic millimetre of blood, out of these cases as many as thirty-one had an index of 71 and over. A reference to table V*a* shows that of these thirty-one cases, twenty belonged to the bronchial group, six to the Gram-negative-bacilli group, and five to the allergic group (these five cases were mixed bronchial and allergic cases). So that all the thirty-one cases in this group were associated with infection. Usually with a shift in the Arneth count to the left, *i.e.*, with an active bone marrow we would expect to get a leucocytosis in the blood. In order to rule out the possibility of the leucopenia in these cases being due not to a decrease in the number of the polymorphonuclears but to a decrease in the other types of cells we have plotted the total polymorphonuclears against the Arneth index in table VI. If we take 5,000 polymorphonuclears in one cubic millimetre of blood to represent roughly the normal figure we see in table VI that the number of cases who had a polymorphonuclear count of below 5,000 was

So that we see that in these cases there is a polymorphonuclear leucopenia and yet a shift in the Arneth count to the left indicating that in spite of the reduction of polymorphonuclear cells in number—young forms are in preponderance.

Cooke (1928) maintains that in all cases of microbic infection there is a left-handed shift in the Arneth count whether the total polymorphonuclears remain normal in number, whether there was a polymorphocytosis or whether there was a polymorphopenia. A shift to the left in the Arneth count with a polymorphopenia therefore must mean that the activity of the bone marrow cannot keep pace with the destruction of these cells. In the tropics many of these cases are subjects who have malaria, kala-azar or hookworm infections.

Piney (1927) is of the opinion that when an infection is intense it depresses the bone marrow and causes a neutrophile leucopenia instead of the usual neutrophile leucocytosis, the latter is characterized by a shift to the left in the Arneth count. In those cases where there is a neutrophile leucopenia with a shift to the left in Arneth's count he considers that there is some toxic agency causing a complete alteration in the process of maturation of the neutrophilic cell.

Ponder (1926) stated the equilibrium in the percentage of cells in the various Arneth classes was in no way dependent on the number of cells in the blood stream. The only essential thing for this equilibrium is that the number of cells entering the circulation be equal to the number leaving it. He discusses all the possible combinations between the rate of production of the polymorphonuclear cells and their removal from the blood stream.

Table Va

Arneth index

Total leucocytes under	60-below	61-65	66-70	71-75	76-80	81-85	86-90	Above 90
5,000	**1**				1	2		11
6,000		**1**		**1** 1	11	2	1	
7,000			**1** 2 11	**3** 2		1 11	2	
8,000		**1** 11		**1** 2	4	1	1	**2** 11
9,000	**1**		**2**	**2** 3	11	1	2 11	1
10,000		**2**	**2** 1 11	**1** 3	**1** 3 11	2		1
11,000				2 11	**1** 2			
12,000	**2** 11		2	7	3	2	2	
13,000				1		1		
14,000	11	**2**		**1** 1		1	**2**	
15,000		**1**	1	2	**1**	11	11	
16,000		11	**1** 11	2 11	11	11	**3** 11	
17,000		**1**	1					11
18,000			**1** 1					
20,000	**1**			**1** 1				
23,000			**1**		1	1	1	
25,000			11			**1**		11
26,000				11				
36,000						**1**		
37,000		1						

1. (ordinary type)=Bronchial cases.
11. (out-lined figures)=Gram-negative-bacilli cases.
1. (bold-face figures)=Allergic *plus* bronchial and allergic cases.

We can thus appreciate (*a*) why a leucocytosis with a normal or sub-normal Arneth's count is seen in asthmatics—and it is due to a high eosinophilia, and (*b*) why, when there is a leucopenia, there is still a shift to the left in the Arneth count.

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