A STUDY IN THE VARIATION OF NORMAL BONE MARROW WITH REFERENCE TO AGE

Submitted as a Thesis for the

M. D. Examination

by

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ACKNOWLEDGEMENTS

This work was carried out while Medical Registrar at Killearn E.M.S. Hospital, in wards under the care of Professor J.W. McNee.

I wish to express my gratitude to Professor McNee for the facilities he offered me both there and at other hospitals, as well as for his helpfulness in criticising the work as it proceeded.

I wish also to thank Dr. C.K. Stevenson, Medical Superintendent of Killearn E.M.S. Hospital, for permission to publish cases under the authority of the Department of Health for Scotland, and also Dr. Thomas Fraser, Visiting Physician to Southern General Hospital, for permission to use clinical material in his wards.

PREFACE

In spite of an exhaustive search in the literature of haematology, I have been able to find but brief reference to the findings in Normal Bone Marrow with reference to age.

The most comprehensive works on this subject have been carried out by N.G. Nordenson, E. Segerdahl, C.M. Plum and K.M. Jacobsen. Other workers, e.g. Arinkin and Barta, do not give any details concerning the material used, but state the normal figures for the differential count in adult bone marrow.

K.M. Jacobsen (1941) studied 88 normal cases with reference to age in the following groups:-

Years	Number Punctured
2-5	6
6-9	7
10-14	5
15-19	7
20-29	28
30-44	19
45-59	9
70-93	7
	88

E. Segerdahl (1935) studied 110 cases divided into three groups:-

Group I	52 men	20-30 years
Group II	40 women	20-30 years
Group III	18 in old age group	(9 men (9 women

No work has been found on normal bone marrow with reference to age, where the material used has been evenly distributed over the age groups from 1-100 years.

The present work consists of 83 cases divided into the following groups:-

Years	Number Punctured
0-9	3
10-19	10
20-29	10
30-39	10
40-49	10
50-59	10
60-69	10
70-79	10
80-99	10
Total :	83

Owing to the difficulties of obtaining suitable material in the age group 0-9 years, it has only been possible to include three cases in this group.

HISTORICAL BACKGROUND

In 1849 C. Robin, described the nucleated cells of the red bone marrow (Médullocelles) and noted their resemblance to the leucocytes of the peripheral blood.

It was not until 1868, however, that E. Neumann studied the bone marrow with reference to blood and showed that the marrow is the site of erythropoiesis (1868) and leukopoiesis (1869). This theory was soon generally accepted.

Thereafter bone marrow was obtained at post-mortem and the changes studied, that occur in the bone marrow during disease. Correlation of the changes in the bone marrow post-mortem and in the blood in vivo soon gave rise to difficulties and in 1908 G. Ghedini published a method of trephining the upper end of the tibia during the life of the patient, sections and smears being made of the curetted marrow.

This method was later simplified by C. Seyfarth in 1923 when he devised a method of trephining the outer lamina of the sternum and removing the marrow with a curette.

Sternal trepanation, however, is in the nature of a major surgical operation and for this reason could not be widely used.

Arinkin in 1929 described the method of puncturing the outer lamina of the sternum with a strong needle and withdrawing 10 c.c.'s of marrow fluid by aspiration for examination. Since then this method, with modifications, has been widely used with satisfactory results, and no complications have been reported.

In 1937 Damashek compared the trephine and puncture methods of obtaining marrow fluid and he considered that trepanation was definitely superior, as the fluid obtained by puncture is relatively acellular due to the admixture of peripheral blood from the marrow sinuses. He showed that the percentage of myeloblasts obtained by the trephine method was higher than that obtained by sternal puncture. In the former method, also, the anatomical relations of the bone marrow remain undisturbed. In spite of these facts most authors are agreed that for routine use any advantages gained by trepanation are outweighed by the ease and simplicity of sternal puncture.

COMPOSITION OF BONE MARROW

The bone marrow consists of two types:-

1. Red marrow, which is actively haemopoietic and is of a soft semi-fluid consistence.
2. Yellow marrow which is fatty and inactive as far as blood formation is concerned.

At birth and for the first 3 to 4 years of life all the bones in the body contain red marrow. Tibial marrow only remains active up to 7 years and becomes completely inactive, due to fatty metamorphosis, by 15 to 20 years (Whitby and Britton (1946), M. Diwany (1940)).

In the adult the red marrow is contained in the bones of the skull, ribs, sternum, scapulae and clavicles, the vertebrae and os innominatum, and a little in the upper end of the humerus and femur (Whitby and Britton 1946).

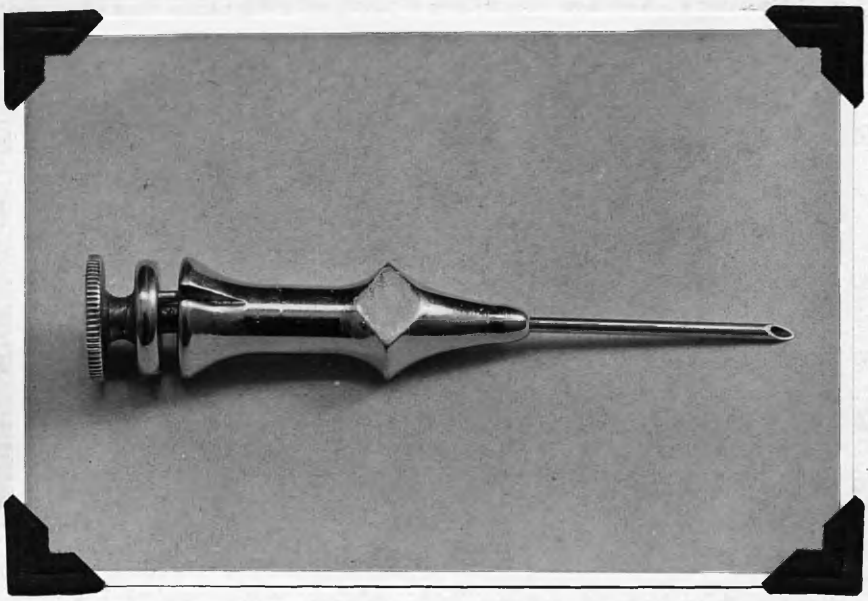
The nutrient artery to the bone marrow breaks up into a network of intercommunicating vessels lined with endothelium, known as sinusoids (Whitby and Britton 1946).

There is a gradual diminution in the amount of red marrow, which becomes replaced by fatty marrow, as age advances, but experimental data reveal that the red marrow remains

relatively normal in the aged (C. Reich, M. Swirsky and D. Smith (1944)).

Custer and Ahlfehldt (1932) have shown that the marrow of the sternum remains active throughout life, although cellularity decreases with advancing years. C. Reich, M. Swirsky and D. Smith (1944) on the other hand are of the opinion that survival to old age requires a good functioning bone marrow, and that cellular activity in the aged is not only normal but is definitely increased in some cases. Segerdahl (1935) states that there is a falling level of all specific marrow elements in old people due to an increase of fatty marrow.

TECHNIQUE



NEEDLE USED. [NATURAL SIZE]

Many types of needles have been devised for sternal puncture and for this study an ordinary Lumbar Puncture needle (18 m.m. bore) with fitting stylet was used, cut down to a length of 2.5 cms. with a short bevel. No guard was used.

A tight-fitting, dry, 2 c.c. record syringe was used for aspiration.

Both in children and adults the 2nd intercostal space midway between the mid-line and the edge of the sternum was

the site of election for diagnostic puncture. The mid-line was not used as fusion of the sternal plates is incomplete in 20% of cases (Pässler 1931) and occasionally union in the mid-line is cartilaginous (Bodley Scott 1939). Before the age of 25 years osseous union between the sternebrae may be incomplete (Bodley Scott 1939) and for this reason the level of the interspace was considered a more suitable site.

The red marrow appears at the 6th month of intra-uterine life as two centres, one on either side of the mid-line. At birth those of the manubrium are fused into one large centre but puncture at this level is not advisable, due to the large vessels which lie behind it (Diwany 1940). The centres in the other segments become fused and this is complete by 6th-10th year (Diwany 1940).

In children the centre at the level of the 2nd interspace is recommended by Diwany (1940) and by Kato (1937) and was used in the present series, but Propp and Schwind (1944) recommend the level of the 3rd interspace on the ground that the 1st and 2nd sternebrae do not, in some individuals, unite until adult life.

The patient lies supine in bed with the head and shoulders supported on a pillow. Only in the case of children was it found necessary to cover the head with a towel.

If necessary, the sternum was shaved and the skin prepared with spirit and iodine.

The forefinger of the left hand was held firmly against the right sternal border to prevent the needle accidentally entering the Pleural Cavity, and between 1 and 2 c.c's of 5% Procaine infiltrated into the skin and underlying tissues, care being taken to infiltrate a small quantity underneath the periosteum. The latter procedure occasionally produced a feeling of discomfort. A short interval was allowed to elapse and the dry needle was held in the right hand with the forefinger held firmly against the needle 1.5 cm. from the point. The stylet was held firmly down into the needle by the palm of the right hand to prevent the entry of spicules of bone into the needle during its passage into the marrow cavity. A gentle rotatory movement was used and, with the exception of certain young adult males, it was not found necessary to use anything but light pressure in order to perforate the anterior lamina of the sternum. When the needle enters the marrow cavity a sudden 'give' is felt and on removing the right hand the needle is found to be standing upright without the operator's support. The stylet is then withdrawn and a dry, tight-fitting, 2 c.c. syringe attached to the end of the needle. The amount of suction required varies from

case to case, but as a rule marrow fluid flows immediately into the barrel of the syringe on withdrawing the plunger. This may be associated with a sharp pain in the chest due to the production of a negative pressure in the marrow cavity, but in many cases the patients experience little beyond a slight sensation of discomfort. 0.1 c.c. of marrow fluid is withdrawn.

Arinkin (1929) in his original description of sternal puncture withdrew 10 c.c's, but most authors are agreed that the withdrawal of more than 0.2 c.c. is unsatisfactory, due to the greater admixture with peripheral blood from the marrow sinuses (Scott 1939, Segerdahl 1935).

Jacobsen (1941) in his study withdrew 0.5 c.c. of marrow fluid. Young and Osgood (1935) withdrew 1-2 c.c's which was subsequently oxalated and smears made. Reich (1935) withdrew 10 c.c.'s of marrow fluid with 2 c.c.'s of 1-4% sodium oxalate. This mixture was centrifuged and smears made.

Reich, Swirsky and Smith (1944) withdrew 4 c.c.'s of marrow fluid which was then oxalated.

Osgood and Seaman (1944) state that it is more accurate to withdraw 1 c.c. of marrow fluid as one withdraws a more uniform mixture of blood and marrow cells from a greater distance away from the site of puncture.

In the present series of cases the marrow fluid was not oxalated but smears were made directly onto clean glass slides which had previously been treated with concentrated Nitric Acid and stored in Absolute Alcohol.

Leishman's Stain was used for staining purposes.

MATERIAL USED

The material used for this study came from 83 cases. These cases on admission to hospital did not suffer from any Haematological condition or any condition known to have a direct influence on the blood picture. The material was mainly drawn from cases of uncomplicated gastric ulcer, non-tuberculous orthopaedic conditions, Psychoneurosis and cases of Pleural Effusion prior to discharge from hospital with negative X-ray pictures and normal E.S.R.

The older age groups were obtained from the wards of a Corporation Hospital for the care of chronic sick. Most of these cases were admitted on account of senility, a few being complicated by Hemiplegia.

All the cases in the present series had a Haemoglobin of 80% or over (Sahli uncorrected), Red Blood cell counts of 4,000,000 or over and a White Cell count within the normal limits of 4,000 to 11,000 as laid down by Whitby and Britten (1946). The peripheral blood differential count was within normal limits (Whitby and Britten 1946).

As no adrenaline was used during local anaesthesia of the sternum, peripheral blood counts were not necessarily performed prior to sternal puncture. This is in agreement with Nordenson (1935).

DESCRIPTION OF BONE MARROW EXAMINATIONS

Quantitative estimations were not carried out, as the following authors considered them valueless: Segerdahl (1935), Mendell and Meranze (1942), Reich and Kolb (1942), Propp and Schwind (1944), Scott (1939).

Segerdahl has published nucleated cell counts on punctures from healthy persons and her mean figures are:-

Men 75,000 per c.mm.

σ = 38,400 per c.mm.

Women 82,700 per c.mm.

σ = 41,100 per c.mm.

Taking the limits of normality as plus or minus 3 times the standard deviation (Yule 1927), the lower limit in each case falls below zero and numerical counts may therefore be taken as being of no statistical significance.

Differential count.

Scott (1939) has shown that no significant variation is found between cell counts from 250-1,000 cells. Mendell and Meranze (1942) first counted 500 cells, but later only 200-300 cells were counted. Cell counts vary widely with different authors, e.g., Jacobsen (1941) counted 2,000 cells.

In the present series 300 cells were counted as no significant variation was found between counts of 300 and 500 cells.

Results are expressed as a percentage of all nucleated cells and cells which could not be classified due to damage, are not included in the figures.

Terminology.

Due to the absence of a universally accepted terminology there is a complete lack of co-ordination in the realm of Haematology. This makes the comparison of results very difficult, as the classification of the cells varies so widely.

The Unitarian school of thought holds that granulocytic and lymphocytic elements are derived from the same primitive cell, e.g., Downey (1932) considers that lymphocytes may be derived from the Myeloblast.

Ehrlich (1910), however, belongs to the theory of Dualism and is supported by such workers as Schridde (1906) and Naegeli (1931). He believes that lymphocytes are derived from lymphatic tissue in the lymph nodes and that granulocytes are derived from Myeloid tissue. He interprets Monocytes as Myeloid elements.

The Trialist theory is held by Aschoff (1913) who stresses the specifity of three different cell types:-

1. Leucocytes
2. Lymphocytes
3. Monocytes.

The classification of the Myeloid cells in the present series follows that of Scott (1939):

Myeloblast
Premyelocyte and
Neutrophile granulocyte.

Neutrophile Granulocytes are divided into the grades suggested by Schilling (1929)

Myelocyte
Young
Band
Segmented.

Eosinophiles are classified as Myelocyte, Young, Band and Segmented.

With ordinary staining methods it was not found possible to distinguish between Lymphoblasts, Monoblasts and Myeloblasts and these cells are all grouped together under the heading of "Myeloblast". Plasma cells are used to include Türck cells (Naegeli 1931).

The classification of the erythroid cells corresponds to that of Davidson, Davis and Innes (1942):-

Erythroblasts
- Type I
- Type II
- Type III
- Type IV

In agreement with Whitby and Britten (1946), Scott (1939), Piney (1942), Stasney and Higgins (1938), Pronp and Schwind (1944) and many other workers, Megaloblasts are not found to be present in normal bone marrow. Piney (1941) states that the cells quoted in his figures as Megaloblasts are really large Normoblasts.

Such workers as Holmes and Broun (1933), Doan and Zerfas (1927), Sabin (1928), Custer (1933), Young and Osgood (1935), Vogel, Erf and Rosenthal (1937), Vaughan (1940) and Weiner (1938), on the other hand, describe Megaloblasts in normal bone marrow.

DESCRIPTION OF CELL TYPES

Myeloblast.

This cell is the precursor of all cells in the Myeloid group. Its size varies from 11μ to 18μ.

The cytoplasm is dark blue in colour and contains no granules which can be seen by the ordinary Romanowsky staining methods.

The nucleus is fairly large and is round or oval. It may lie eccentrically, is rather poor in chromatin and shows a finely reticular structure. There is no distinct nuclear membrane. A perinuclear zone may be present /Nordenson (1935)/. The nucleus usually contains several nucleoli which stain a pale blue colour.

Both macro and micro forms may be found.

Pre-myelocytes.

This is the transition cell between Myeloblasts and Myelocytes. It resembles the Myeloblast in that the cytoplasm stains a dark blue, and the nucleus is round or oval and has the same finely reticular structure. A few immature granules which stain a pale pink colour (acidophilic) are present. In

some cases these granules are easily identified, but in other cases careful focussing with the microscope is necessary for their identification.

Both macro and micro forms may be found.

Myelocytes.

This cell varies greatly in size, both macro and micro forms being identifiable.

The cytoplasm is pinkish in colour and contains numerous ripe granules which may be Eosinophilic, Basophilic or Neutrophilic, depending on the type of segmented cell to which it will give rise.

The nucleus is round, oval or kidney-shaped and occupies about one half of the cell. It does not contain any nucleoli and does not stain as intensely as the nucleus of a mature Polymorph.

Young cell.

Both macro and micro forms may be found. The cytoplasm is pinkish in colour and mature granules are present as described in the Myelocyte forms. The nucleus shows a well-marked indentation and the border of nuclear tissue usually lies towards the periphery of the cell.

Band cell.

The cytoplasm is mature and the nucleus is absolutely ripe, but has not yet begun to segment. It usually assumes bizarre forms.

Both macro and micro forms may be found.

Polymorphs.

These are the mature, segmented granulocytes. Average size is 10μ to 12μ. Granulation may be Neutrophilic, Eosinophilic or Basophilic, and the nucleus shows marked variation in shape, but is characterised by two or more lobes attached by filaments of nuclear material.

Lymphocytes.

For the purpose of this study large and small lymphocytes have been classified together.

The cytoplasm stains a pale blue colour and is scanty in small lymphocytes, but is more abundant in large lymphocytes. It usually contains a few coarse, bluish granules.

The nucleus stains very deeply and is usually round or may show slight indentation. It is composed of heavy masses of chromatin with more lightly staining areas between these masses.

Monocytes.

These resemble the Monocytes of peripheral blood, and in marrow films are infrequently found.

The size varies from 16μ to 22μ. The cytoplasm stains a pale greyish blue and sometimes contains reddish blue granules.

The nucleus is round or oval and may be lobulated or horse-shoe shaped. It stains a pale violet colour and the chromatin arrangement may be described as resembling "a ball of twine".

Megakaryocytes.

As a rule this is the largest cell in a marrow smear, but smaller forms may also be found.

The cytoplasm is greyish in colour and contains fine azurophil granules. It contains several small nuclei which may form an irregular ring.

Plasma cell (including Türck cell).

This cell is larger than the large lymphocyte and has a deeply Basophilic cytoplasm which often contains one small vacuole. The nucleus is markedly eccentric and is composed of chromatin which may or may not have a cart-wheel arrangement.

Erythroblast Type I.

A large cell (average 18μ diameter) with a variable amount of deep blue cytoplasm. No granules are present.

The nucleus (14.2μ) is composed of finely reticulated, scroll-like masses of chromatin.

The cytoplasm of this cell stains, as a rule, a more intense blue than that of the Myeloblast and the nucleus has a less finely reticular appearance.

Type II.

A somewhat smaller cell (average 14.2μ diameter).

The cytoplasm is either basophilic or polychromatic, and contains no granules.

The nucleus is basophilic (10.3μ diameter) and more deeply staining than in Type I. The chromatin is coarser and denser with a tendency to form lumpy masses, but a reticular character is still preserved. No nucleoli are present.

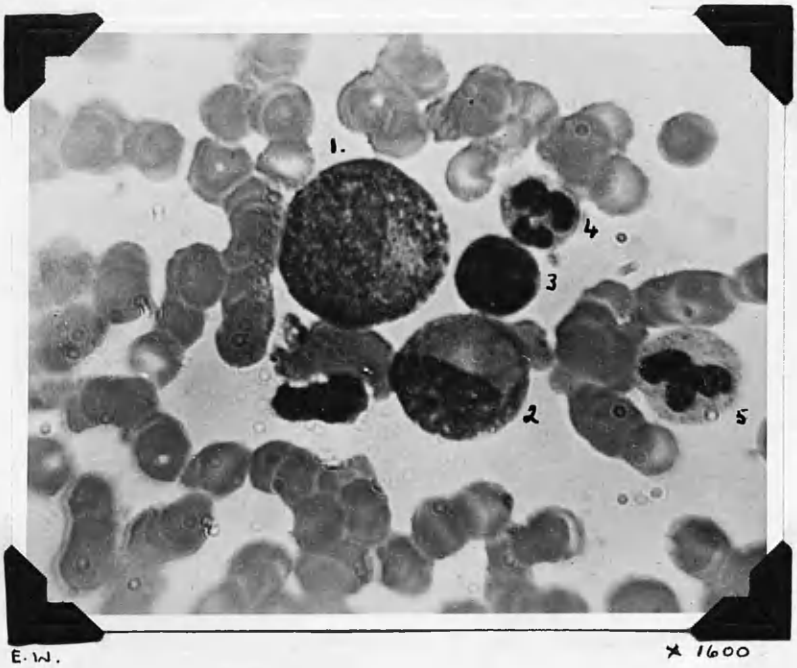
Type III.

This is a smaller cell (average 11.1μ diameter) of which the cytoplasm is usually polychromatic, but may be basophilic or orthochromatic. The nucleus (average 7.3μ diameter) is

very deeply staining and is composed of a condensed lumpy mass of chromatin, which may exhibit a cart-wheel arrangement.

Type IV.

This is a small cell (average 9.3μ diameter) with polychromatic or orthochromatic cytoplasm and a pyknotic nucleus (average 4.8μ diameter).



E.W. × 1600

1. MYELOCYTE MACRO FORM.

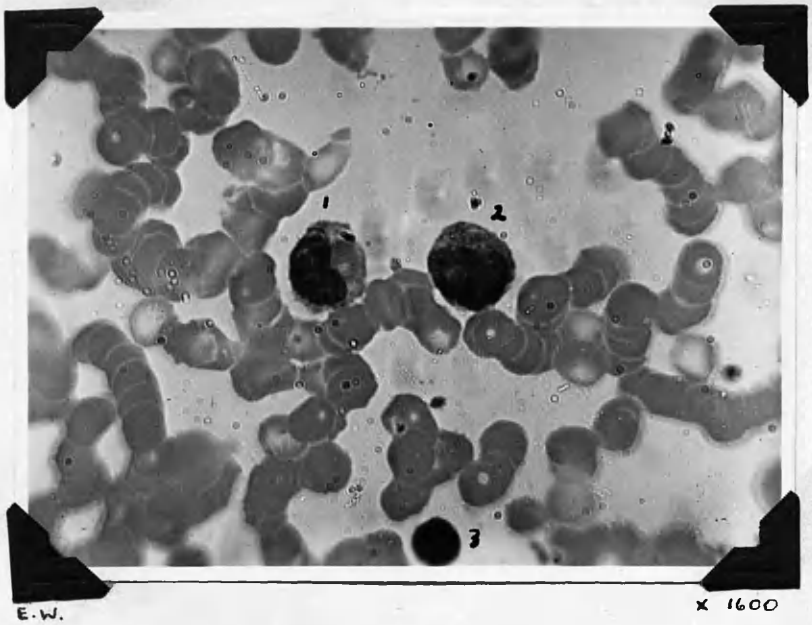
2. MYELOCYTE.

3. LYMPHOCYTE.

4. POLYMORPH.

5. BAND.

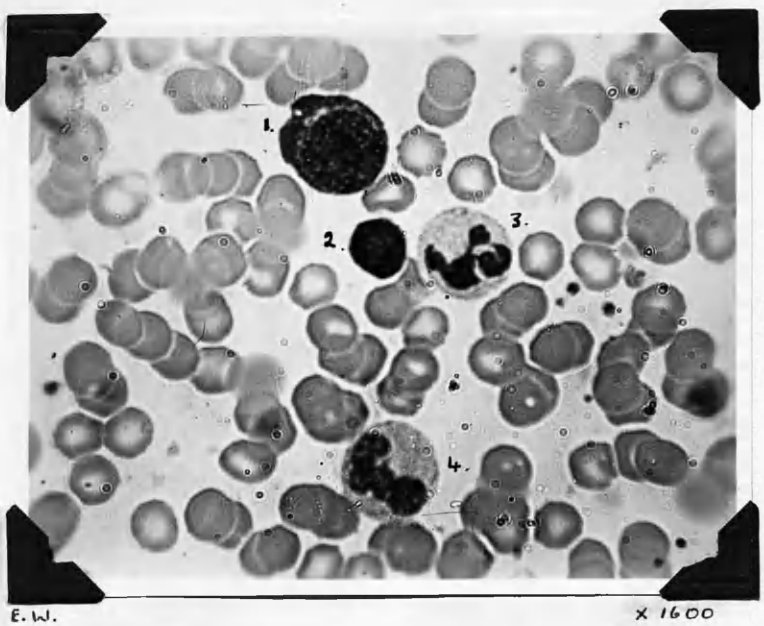
Not a very good photo



1. MYELOCYTE WITH KIDNEY-SHAPED NUCLEUS.

2. MYELOCYTE.

3. LYMPHOCYTE.

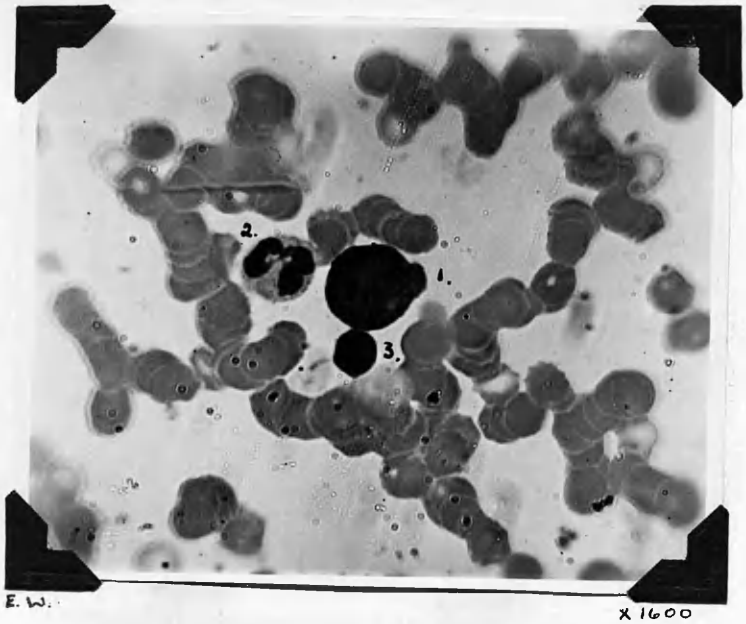


1. ERYTHROBLAST TYPE I.

2. LYMPHOCYTE.

3. POLYMORPH.

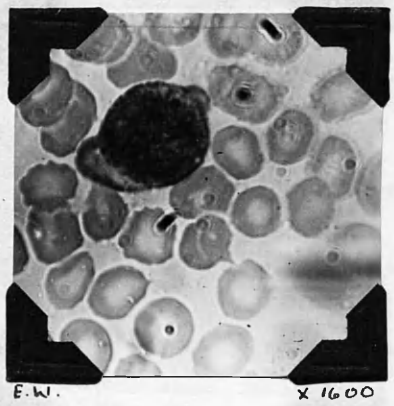
4. BAND.



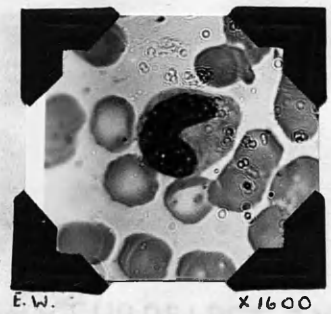
1. ERYTHROBLAST TYPE II.

2. POLYMORPH.

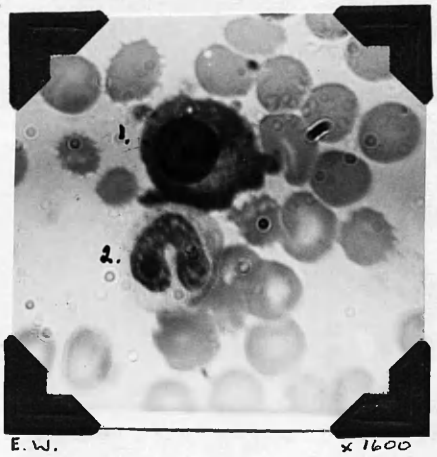
3. LYMPHOCYTE.



MYELOBLAST.

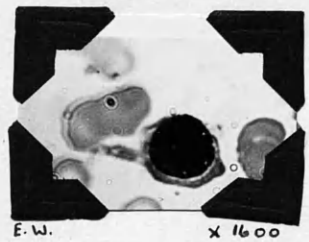


YOUNG.

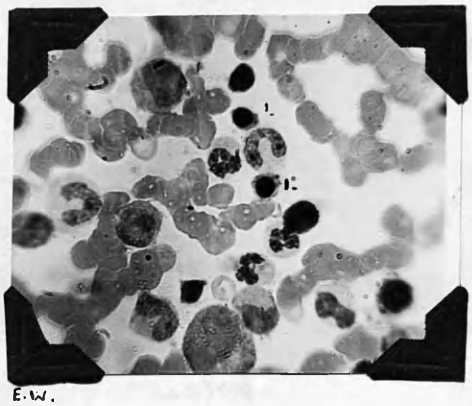


1. TÜRCK.

2. YOUNG.



ERYTHROBLAST TYPE III.



GENERAL FIELD. [LOW POWER].

1. ERYTHROBLAST TYPE IV.

Leuko-erythrogenetic Ratio.

The Leuko-erythrogenetic Ratio is recommended by Scott (1939) as a reliable figure in analysing Sternal puncture counts. This figure represents the ratio between the immature cells of the granulocyte series from Myeloblast to young neutrophile forms inclusive, and that of the percentage of Erythroblasts. Errors due to dilution with circulating blood are thus eliminated.

In the present study the leuko-erythrogenetic ratio by age has been calculated.

Myeloid and Erythroid Dispersions.

These are expressed by stating the percentile proportions of Myeloblasts, pre-myelocytes, neutrophile Myelocytes, and Young, found taking the sum of the percentage of these cells in the total count as 100.

In the Erythroblast series the percentage of the total number of cells represented severally by Type I, Type II, Type III and Type IV will express the maturity dispersion. For this purpose Type III and Type IV are grouped together (Scott 1939).

CASE HISTORIES

0 - 9 Years

1. THELMA R - Aged 6 years.

Admitted to hospital with Peripheral nerve injury to left arm.

Examination of heart, lungs, throat and abdomen revealed no abnormality.

Sternal puncture 3 months after admission to hospital.

2. JANE K - Aged 5 years.

Admitted to hospital with Peripheral nerve injury to right arm.

Physical examination negative.

S.P. 4 months after admission to hospital.

3. MARGARET G - Aged 5 years.

Admitted to hospital with Cerebellar Astrocytoma which was successfully removed at operation.

Examination of heart, lungs and abdomen revealed no abnormality.

S.P. shortly before dismissal.

10 - 19 Years.

4. Miss McA - Aged 17 years.

Admitted to hospital for convalescence following left Pleural effusion. Physical examination of chest revealed no abnormality.

X-ray examination: No effusion but Pleural thickening at left base.

E.S.R. 10 mm/hour.

S.P. after a period of 6 weeks convalescence.

5. Mr. W - Aged 15 years.

Admitted to hospital with a history of Frontal headaches of 4 years' duration following a bicycle accident.

Blood Pressure = $\frac{120}{88}$ mm/Hg.

X-ray skull: negative

X-ray sinuses: negative

Electroencephalogram: negative.

Physical examination: negative.

Final diagnosis of Neurosis was made.

S.P. prior to discharge from hospital.

6. Mr. Y - Aged 17 years.

Admitted to hospital on account of a head injury 3 years previously which was followed by left hemiparesis. He still complains of weakness of the left side but examination of the central nervous system reveals no abnormality. Both grips are satisfactory.

Fundi: normal.

Blood Pressure $\frac{130}{70}$ mm/Hg.

Final diagnosis of Neurosis.

S.P. prior to discharge.

7. Mr. H - Aged 18 years.

Admitted to hospital with fracture of right femur and injury to right wrist. Physical examination otherwise negative.

S.P. prior to discharge home.

8. Mr. D - Aged 13 years.

Admitted to hospital on account of spastic flat foot.

Physical examination otherwise negative.

9. Mr. C - Aged 17 years.

Admitted to hospital with bilateral Genu Valgum for operative treatment.

Physical examination otherwise negative.

10. Miss H - Aged 15 years.

Admitted to hospital with history of Tapeworm of one year's duration. Following treatment the head of the worm was procured. Physical examination otherwise negative.

S.P. prior to discharge.

11. Mr. C - Aged 16 years.

Member of hospital staff who was willing to have Sternal Puncture performed.

Physical examination negative.

12. Miss McC - Aged 18 years.

Admitted to hospital with Right Hallux Valgus for operative treatment.

Physical examination negative.

S.P. prior to operation.

13. Miss B - Aged 12 years

Admitted to hospital for convalescent treatment following a history of vague rheumatic pains and swelling of both feet.

Physical examination negative and no signs of rheumatism detected.

E.S.R. 5 mm/hour. Temperature normal.

S.P. prior to discharge after a period of 2 weeks' convalescence.

20 - 29 Years.

14. Mr. McC - Aged 26 years.

Admitted to hospital with gunshot wound of right ankle.

No fracture.

Physical examination otherwise negative.

S.P. while convalescent.

15. Mr. R - Aged 22 years.

Admitted to hospital with fracture of Right Tibia.

Physical examination otherwise negative.

S.P. while convalescent.

16. Mr. M - Aged 24 years.

Admitted to hospital with vague history of gastric dyspepsia.

Perforation 2 months prior to admission to hospital.

Fractional test meal showed normal acidity.

Barium meal revealed no active ulcer present.

Physical examination negative.

S.P. prior to discharge.

17. Mr. C - Aged 23 years.

Admitted to hospital with fracture of Pelvis and right Humerus following motor accident.

Physical examination otherwise negative.

S.P. while convalescent.

18. Miss B - Aged 20 years.

Admitted to hospital with history of Asthma since childhood for investigation. No asthmatic attacks during stay in hospital.

X-ray chest negative.

Physical examination negative.

Blood Pressure $\frac{132}{94}$. mm/Hg.

Peripheral blood film showed no eosinophilia.

S.P. prior to discharge.

19. Miss P - Aged 22 years.

Admitted to hospital with left Pleural effusion.

S.P. when effusion had cleared and X-ray examination of chest revealed only Pleural thickening at the left base.

E.S.R. 8 mm/hour.

20. Mr. B - Aged 28 years.

Admitted to hospital with history of epigastric pain 1 - 2 hours after food of one year's duration.

Fractional Test meal showed high acidity.

Barium meal, Active Duodenal Ulcer present.

Physical examination otherwise negative.

S.P. following treatment and when Barium meal showed that the ulcer had healed.

21. Mr. W - Aged 26 years.

Admitted to hospital with loose right internal Meniscus which was subsequently removed at operation.

Physical examination otherwise negative.

S.P. prior to discharge from hospital.

22. Mrs. D - Aged 29 years.

Admitted to hospital with history of epigastric pain of 4 years' duration, nausea and flatulence.

Barium meal revealed no abnormality.

X-ray of Gall-bladder showed a single cholesterol stone in Gall-bladder.

No operative treatment desired.

Physical examination otherwise negative.

S.P. prior to discharge.

23. Mr. McN - Aged 23 years.

Admitted to hospital with history of vague epigastric pain half an hour after food since 1937. Also history of right Pleural effusion 2 years previously.

Fractional test meal showed a high climbing acidity.

Barium meal: No ulcer present.

X-ray Chest showed Pleural thickening at left base.

E.S.R. 2 mm/hour.

Physical examination negative.

S.P. prior to discharge.

30 - 39 Years.

24. Miss L - Aged 32 years.

Admitted to hospital with history of 'fits' of 6 months' duration.

Blood Pressure $\frac{120}{80}$ mm/Hg.

Central Nervous System showed no abnormality.

Fundi: normal

X-ray skull showed expanded Sella Turcica in manner of Pituitary neoplasm.

25. Mr. H - Aged 32 years.

Admitted to hospital on account of Disseminated Sclerosis. This was confirmed by examination of the central nervous system.

Examination of heart and lungs revealed no abnormality.

26. Mr. McF - Aged 31 years.

Admitted to hospital with history of Dyspepsia of 15 years' duration.

Fractional test meal showed high acidity.

Barium meal no active ulcer present.

Physical examination otherwise negative.

S.P. prior to discharge.

27. Mr. D - Aged 34 years.

Admitted to hospital with compound fracture of Right Leg.

Physical examination otherwise negative.

S.P. during convalescence.

28. Mr. L - Aged 35 years.

Admitted to hospital with a history of epigastric pain and sickness of 3 years' duration.

Fractional test meal showed a moderately high acidity.

Barium meal: Duodenal ulcer present.

Physical examination otherwise negative.

S.P. prior to discharge when Barium meal examination showed that the ulcer had healed.

29. Mr. P - Aged 38 years.

Admitted to hospital with a history of vomiting and epigastric pain half an hour before food of 9 years' duration.

Fractional test meal showed a moderately high acidity.

Barium meal: Active Duodenal Ulcer present.

S.P. prior to discharge when Barium meal examination showed that the ulcer had healed.

30. Mr. C - Aged 36 years.

Admitted to hospital with history of "nerves" of 4 years' duration. Vague gastric symptoms of 2 years' duration. Patient had been under the care of a Psychiatrist.

Fractional test meal showed normal acidity.

Barium meal: no ulcer present.

Physical examination negative.

S.P. prior to discharge.

31. Miss C - Aged 34 years.

Admitted to hospital with history of right-sided Sciatica of 4 weeks' duration.

Otherwise physical examination negative.

E.S.R. 5 mm/hour.

S.P. following treatment and prior to discharge.

32. Mr. D - Aged 31 years.

Admitted to hospital with history of Tapeworm. Following treatment the head of the worm was not procured.

S.P. prior to discharge.

33. Mr. R - Aged 31 years.

Admitted to hospital with history of gastric ulcer one year previously. No symptoms on admission.

Physical examination negative.

Fractional test meal shows normal acidity.

Barium meal: slight deformity of the Duodenal cap. No ulcer seen.

S.P. prior to discharge.

40 - 49 Years

34. Mr. A - Aged 43 years.

Admitted to hospital with history of headaches over right Parietal region of six months' duration.

Blood pressure $\frac{142}{80}$ mm/Hg.

X-ray Skull and Sinuses negative.

Cerebrospinal fluid normal.

Examination of central nervous system revealed no abnormality.

S.P. prior to discharge from hospital.

35. Mr. K - Aged 47 years.

Admitted to hospital with history of comminuted fracture of upper $\frac{1}{3}$ and lower $\frac{1}{3}$ Left Tibia.

Physical examination otherwise negative.

S.P. during convalescence.

36. Mr. B - Aged 41 years.

Admitted to hospital with Duodenal Ulcer of 5 years' duration.

Fractional test meal showed a high acidity.

Barium meal: Duodenal ulcer present.

Physical examination otherwise negative.

S.P. prior to discharge when Barium meal examination showed that the ulcer had healed.

37. Mr. W - Aged 49 years.

Admitted to hospital with a history of gastric trouble of 20 years' duration.

Fractional test meal showed a high acidity.

Barium meal: Active Duodenal Ulcer present.

Physical examination otherwise negative.

S.P. prior to discharge when Barium meal examination showed that ulcer had healed.

38. Mr. T - Aged 44 years.

Admitted to hospital on account of abdominal pains.

X-ray of abdomen showed left Renal calculus. No hydronephrosis.

Renal function good.

Urine showed no abnormality.

Blood pressure $\frac{122}{80}$ mm/Hg.

Physical examination otherwise negative.

S.P. prior to operation.

39. Mrs. C - Aged 42 years.

Admitted to hospital with Left Renal calculus with hydronephrotic kidney.

Urine contained albumen but culture was sterile.

39 (continued)

Microscopic urinary deposit contained no significant abnormality.

Blood pressure $\frac{120}{70}$ mm/Hg.

Physical examination otherwise negative.

S.P. prior to operation.

40. Mr. McE - Aged 49 years.

Admitted to hospital with a history of spasmodic Torticollis of 3 months' duration.

Blood pressure $\frac{145}{96}$ mm/Hg.

Wasserman reaction negative.

Physical examination negative.

Following suggestion under sodium pentothal the Torticollis disappeared.

S.P. prior to discharge.

41. Mr. McI - Aged 42 years.

Admitted to hospital for Right internal meniscectomy.

Physical examination otherwise negative.

S.P. following operation.

42. Mr. O'D - Aged 45 years.

Admitted to hospital with fracture of Left Femur.

Physical examination otherwise negative.

S.P. during convalescence.

43. Mr. McK - Aged 46 years.

Admitted to hospital with history of epigastric pain of 8 months' duration.

Fractional test meal shows a high acidity.

Barium meal: Duodenal ulcer present.

Physical examination otherwise negative.

S.P. prior to discharge when Barium meal showed that the ulcer had healed.

50 - 59 Years.

44. Mr. S - Aged 51 years.

Admitted to hospital with a history of Duodenal ulcer 3 years ago and a recurrence of epigastric pain.

Fractional test meal shows normal acidity.

Barium meal: healed Duodenal ulcer. No activity.

Physical examination otherwise negative.

S.P. prior to discharge.

45. Mr. McG - Aged 59 years.

Admitted to hospital with fracture of left Femur.

Physical examination otherwise negative.

S.P. during convalescence.

46. Miss McK - Aged 53 years.

Admitted to hospital with gastric history of 7 years' duration.

Fractional test meal showed normal acidity.

Barium meal: large Duodenal ulcer.

Physical examination otherwise negative.

S.P. prior to discharge when Barium meal examination showed that the ulcer had healed.

47. Mr. McD - Aged 54 years.

Admitted to hospital with fracture dislocation of 7th and 8th Dorsal vertebrae and paraplegia.

No urinary infection.

S.P. during convalescence.

48. Mr. G - Aged 52 years.

Admitted to hospital with history of cramp-like pain in both legs after walking 200 yards of 18 months' duration.

Blood pressure $\frac{210}{110}$ mm/Hg.

X-ray showed no calcification of arteries of legs.

Physical examination otherwise negative.

S.P. prior to discharge.

49. Mr. L - Aged 54 years.

Admitted to hospital on account of occasional attacks of vomiting of 15 years' duration.

Fractional test meal: normal acidity.

Barium meal: normal.

Physical examination negative.

S.P. prior to discharge.

50. Mrs. G - Aged 56 years.

Admitted to hospital on account of right-sided Hemiplegia following ? cerebral aneurysm.

Blood pressure $\frac{105}{70}$ mm/Hg.

Cerebrospinal fluid: Xanthochromic.

S.P. prior to discharge when patient is convalescent and movement of right side is greatly improved.

51. Mrs. G - Aged 56 years.

Admitted to hospital on account of Essential Hypertension.

Renal function is satisfactory.

Blood pressure $\frac{250}{150}$ mm/Hg.

Physical examination otherwise negative.

52. Mr. C - Aged 50 years.

Admitted to hospital with torn internal cartilage of right knee.

Physical examination otherwise normal.

S.P. prior to discharge.

53. Mr. C - Aged 52 years.

Admitted to hospital with history of headaches and giddiness.

Physical examination negative.

Blood pressure $\frac{120}{80}$ mm/Hg.

Cerebrospinal fluid normal.

X-ray sinuses negative.

Electroencephalogram normal.

S.P. prior to discharge.

60 - 69 Years.

54. Mr. G - Aged 67 years.

Admitted to hospital with fracture of left Femur.

Physical examination otherwise negative.

S.P. during convalescence.

55. Mrs. C - Aged 66 years.

Admitted to hospital with intracapsular fracture of neck of right Femur.

Physical examination otherwise negative.

S.P. during convalescence.

56. Miss McK - Aged 66 years.

Admitted to hospital with transcervical fracture of neck of right Femur.

Physical examination otherwise negative.

S.P. during convalescence.

57. Mrs. McM - Aged 67 years.

Admitted to hospital with Potts fracture of right leg.

Physical examination otherwise negative.

S.P. during convalescence.

58. Mr. G - Aged 63 years.

Admitted to hospital with history of vague rheumatic pains in hands, shoulders and neck of 7 years' duration.

No joint swellings.

E.S.R. 2 mm/hour.

Physical examination negative.

S.P. prior to discharge.

59. Miss McE - Aged 65 years.

Admitted to hospital with old history of Duodenal ulcer and hour-glass contraction of stomach.

Fractional test meal showed normal acidity.

Barium meal: no active ulcer present.

Physical examination otherwise negative.

S.P. prior to discharge.

60. Miss W - Aged 66 years.

Admitted to hospital on account of Hypertension with cerebral softening. Left facial palsy and increased tendon jerks in left arm.

Patient is doubly incontinent.

Blood pressure $\frac{190}{120}$. mm/Hg.

61. Miss F - Aged 62 years.

Admitted to hospital with left Hemiplegia of 7 years' duration and right Hemiplegia of 3 years' duration,

Right arm and both legs paralysed.

Blood pressure $\frac{170}{104}$ mm/Hg.

62. Miss G - Aged 66 years.

Admitted to hospital with Paraplegia.

Patient is Aphasic and is incontinent of urine.

Blood pressure $\frac{210}{110}$ mm/Hg.

63. Mr. T - Aged 62 years.

Admitted to hospital with fracture of neck of left Femur.

Physical examination otherwise negative.

S.P. during convalescence.

70 - 79 Years.

64. Mr. M - Aged 72 years.

Admitted to hospital for Arthrodesis of left hip on account of Osteoarthritis.

E.S.R. 8 mm/hour.

Physical examination otherwise negative.

S.P. when convalescent.

65. Mrs. U - Aged 70 years.

Admitted to hospital with fracture of left Femur.

Physical examination otherwise negative.

S.P. when convalescent.

66. Mrs. F - Aged 74 years.

Admitted to hospital with fracture of neck of right Femur.

Physical examination otherwise negative.

S.P. when convalescent.

67. Mrs. H - Aged 71 years.

Admitted to hospital with cerebral softening.

Physical examination negative.

Patient is senile.

68. Mr. H - Aged 78 years.

Admitted to hospital with fracture of left Femur.

Physical examination otherwise negative.

S.P. when convalescent.

69. Mr. E - Aged 78 years.

Admitted to hospital with right-sided Hemiplegia.

Blood pressure $\frac{140}{70}$ mm/Hg.

70. Mrs. H - Aged 71 years.

Admitted to hospital with Senility.

Physical examination negative.

71. Miss P - Aged 78 years.

Admitted to hospital with Senility and Incontinence of urine.

Blood pressure $\frac{150}{90}$ mm/Hg.

Physical examination negative.

72. Miss B - Aged 73 years.

Admitted to hospital on account of Cerebral Degeneration.

Upper motor neurone lesion of right side.

Incontinent of urine.

73. Mrs. S - Aged 79 years.

Admitted to hospital on account of Senility.

Physical examination negative.

80 - 99 Years.

74. Mrs A - Aged 80 years.

Admitted to hospital with Fracture of neck of left Femur.

Physical examination otherwise negative.

S.P. during treatment.

75. Mrs. G - Aged 80 years.

Admitted to hospital on account of Senility.

Physical examination negative.

76. Mrs. McP - Aged 84 years.

Admitted to hospital with Senility and mental degeneration.

Doubly incontinent.

Wasserman reaction negative.

Arms are spastic.

77. Mrs. R - Aged 81 years.

Admitted to hospital with Senility.

Patient confused and restless.

Physical examination is negative.

78. Mrs. McN - Aged 86 years.

Admitted to hospital with senility. Patient is restless and incontinent of urine.

Physical examination negative.

79. Mrs. M - Aged 93 years.

Admitted to hospital on account of senility.

Blindness of several years' duration.

Area of cardiac dulness is enlarged otherwise physical examination is negative.

Blood pressure $\frac{165}{120}$ mm/Hg.

80. Miss G - Aged 82 years.

Admitted on account of senility.

Heart sounds of poor quality.

Blood pressure $\frac{150}{100}$ mm/Hg.

81. Miss B - Aged 90 years.

Admitted on account of senility.

Heart sounds of poor quality.

Blood pressure $\frac{160}{95}$ mm/Hg.

82. Mrs. C - Aged 91 years.

Admitted to hospital on account of senility.

Heart sounds of poor quality.

Blood pressure $\frac{150}{100}$ mm/Hg.

83. Mrs. McA - Aged 80 years.

Admitted to hospital with Right Hemiplegia.

Blood pressure $\frac{220}{110}$ mm/Hg.

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Peripheral Blood Examination

Case No.	Blood Count			Differential					
				Polymorph					
	Hb %	R.B.C.	W.B.C.	Neutro- phile %	Eosino- phile	Baso- phile	Small Lymphocyte	Large Lymphocyte	Mononuclear
1.	96	4,590,000	7,600	68	1	-	10	20	1
2.	90	4,440,000	7,600	72	-	-	14	10	4
3.	108	5,030,000	9,400	74	-	-	16	6	4
4.	98	5,060,000	8,200	63	1	-	19	14	3
5.	98	5,270,000	6,000	56	-	-	18	18	8
6.	80	4,010,000	7,800	62	-	-	20	14	4
7.	86	4,340,000	6,600	58	1	-	28	6	7
8.	88	4,680,000	6,000	77	1	-	10	9	3
9.	100	4,540,000	8,800	68	1	-	15	12	4
10.	94	4,960,000	9,000	62	2	-	18	14	4
11.	100	5,120,000	7,200	72	-	-	16	6	6
12.	80	4,360,000	6,000	67	-	-	23	4	6
13.	88	4,770,000	9,200	74	-	-	14	10	2
14.	100	5,530,000	6,400	71	-	-	19	6	4
15.	90	4,420,000	7,400	62	2	-	14	14	8
16.	96	4,740,000	8,200	74	-	-	10	10	6
17.	98	4,630,000	7,400	70	-	1	11	14	4
18.	102	5,160,000	9,500	75	-	-	15	4	6
19.	90	4,540,000	8,600	71	-	-	18	5	6
20.	104	5,580,000	8,000	74	-	-	10	8	8
21.	94	4,480,000	7,200	70	-	-	20	8	2
22.	98	5,060,000	9,000	72	1	-	17	6	4
23.	90	4,340,000	8,000	60	-	-	22	12	6
24.	95	4,690,000	7,800	72	-	-	20	6	2

Blood Count				Differential					
				Polymorph					
Case No.	Hb %	R.B.C.	W.B.C.	Neut- % ro- phile	Eosino- phile	Baso- phile	Small Lymphocyte	Large Lymphocyte	Mono- nuclear
25.	106	5,840,000	6,000	69	-	-	21	8	2
26.	96	4,770,000	8,600	72	1	-	20	2	5
27.	80	4,270,000	6,000	66	-	-	22	11	1
28.	94	4,220,000	8,000	68	-	-	22	10	-
29.	92	4,680,000	8,200	70	1	-	12	10	7
30.	98	4,640,000	8,500	67	-	-	11	14	8
31.	82	4,450,000	8,800	74	-	-	10	10	6
32.	98	4,890,000	9,000	75	-	-	14	9	2
33.	92	5,040,000	6,600	69	1	-	18	6	6
34.	104	5,120,000	6,000	69	-	-	15	10	6
35.	92	4,560,000	7,000	70	-	-	20	6	4
36.	92	5,040,000	7,400	75	2	1	14	4	4
37.	100	4,960,000	8,200	73	-	-	16	10	1
38.	90	5,140,000	8,000	69	-	-	17	7	7
39.	80	4,410,000	8,600	80	-	-	14	4	2
40.	84	4,100,000	5,000	67	-	-	21	9	3
41.	94	4,550,000	6,400	66	-	-	24	6	4
42.	94	4,750,000	7,400	72	-	-	16	11	1
43.	94	4,560,000	8,400	68	2	-	26	2	2
44.	106	5,660,000	8,600	78	-	-	14	5	3
45.	90	4,480,000	8,200	69	1	-	20	2	8
46.	95	5,120,000	8,200	77	1	-	18	3	1
47.	88	4,620,000	7,800	78	-	-	16	4	2
48.	90	4,810,000	7,800	63	1	-	20	11	5
49.	104	4,830,000	7,000	70	-	-	12	10	8
50.	82	4,730,000	5,400	59	1	-	27	5	8
51.	102	4,640,000	7,400	62	-	-	24	10	4
52.	84	4,110,000	5,800	78	-	-	10	11	1
53.	92	4,860,000	7,800	61	-	-	25	11	3
54.	80	4,200,000	5,000	69	-	-	20	2	9

Case No.	Hb %	R.B.C.	W.B.C.	Differential					
				Polymorph			Small Lymphocyte	Large Lymphocyte	Mono-nuclear
				Neutrophile %	Eosinophile	Basophile			
55.	86	4,450,000	8,200	63	-	-	20	13	4
56.	82	4,200,000	6,200	77	2	-	14	6	1
57.	98	4,740,000	8,000	72	-	-	10	11	7
58.	80	4,110,000	8,200	66	1	-	22	10	1
59.	86	4,700,000	6,600	67	1	-	26	4	2
60.	84	4,020,000	7,000	67	2	-	16	12	3
61.	80	4,110,000	7,600	67	1	-	26	4	2
62.	88	4,820,000	7,600	73	-	-	16	1	10
63.	80	4,020,000	7,000	67	-	-	22	8	3
64.	96	4,500,000	5,200	66	-	-	20	10	4
65.	80	4,090,000	8,400	68	-	-	20	4	8
66.	98	4,890,000	6,000	76	-	-	14	8	2
67.	84	4,120,000	6,000	64	1	-	22	10	3
68.	100	4,880,000	6,600	71	1	-	13	10	5
69.	92	4,460,000	7,000	64	2	-	24	8	2
70.	84	4,210,000	7,600	79	1	-	14	2	4
71.	98	4,520,000	5,000	70	-	-	15	12	3
72.	80	4,300,000	5,800	65	-	-	15	12	8
73.	96	4,880,000	6,000	68	-	-	16	14	2
74.	92	4,670,000	7,000	70	1	-	15	9	5
75.	88	4,200,000	6,000	58	-	-	21	10	11
76.	80	4,000,000	6,400	69	-	-	26	2	3
77.	86	4,090,000	5,600	66	1	-	21	5	7
78.	72	3,920,000	6,800	61	-	1	20	10	8
79.	98	4,660,000	5,800	64	-	-	22	7	7
80.	78	4,040,000	6,800	52	-	-	30	10	8
81.	86	4,110,000	8,000	75	-	-	15	4	6
82.	94	4,640,000	6,000	61	1	-	25	6	7
83.	80	4,360,000	7,200	60	-	-	21	10	9

The following tables show the Bone Marrow findings in the 83 cases selected for investigation:-

Age Group 0 - 9 years

Case Number	Myeloblast %	Pre-myelocyte %	Myelocyte		Young		Band		Polymorph		Lymphocyte %	Monocyte %	Türck %	Megakaryocyte %	Erythroblast Cells			
			Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %					Type I %	Type II %	Type III %	Type IV %
1.	0.3	1.3	2.0	21.3	0.7	11.7	0.3	13.3	1.7	7.3	23.7	-	-	-	0.7	-	8.3	7.3
2.	0.7	2.0	2.0	25.0	-	12.7	1.0	14.7	0.7	8.3	19.3	-	-	-	0.3	1.0	7.7	4.7
3.	-	3.0	-	25.3	0.3	13.3	-	11.3	0.3	5.7	22.0	0.3	0.7	-	1.0	1.0	7.0	8.7
Mean = 0.33		2.10	1.33	23.87	0.33	12.57	0.43	13.10	0.90	7.10	21.67	0.10	0.23	-	0.67	0.67	7.67	6.90

Age Group 10 - 19 years

Case Number	Age in years	Myeloblast %	Pre-myelocyte %	Myelocyte		Young		Band		Polymorph		Lymphocyte %	Monocyte %	Turck %	Megakaryocyte %	Erythroblast Cells			
				Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %					Type I %	Type II %	Type III %	Type IV %
4.	17	0.7	3.0	1.7	29.3	0.3	17.0	-	18.0	0.3	7.0	7.7	-	0.7	-	2.3	1.3	2.3	8.3
5.	15	0.3	3.3	1.7	27.3	0.3	8.7	-	11.3	-	10.0	11.3	-	-	-	0.3	1.0	6.7	17.7
6.	17	0.3	3.3	2.3	42.7	-	10.0	0.3	10.0	1.3	7.0	10.0	-	0.7	-	-	-	6.0	6.0
7.	18	1.0	2.3	0.7	29.7	0.3	5.3	0.3	9.3	0.3	8.3	21.0	-	1.0	-	0.3	2.0	2.7	15.3
8.	13	0.3	2.0	2.3	40.3	0.3	6.7	-	8.3	0.3	9.7	12.7	-	1.0	0.3	1.0	0.7	2.3	11.7
9.	17	1.0	4.0	3.0	27.0	0.3	15.0	1.0	17.0	0.7	7.3	10.0	0.3	1.0	-	0.3	1.3	3.7	7.0
10.	15	0.3	3.3	0.3	33.0	-	12.3	-	9.0	0.3	10.7	9.7	-	0.7	0.7	-	0.3	1.3	18.0
11.	16	0.3	1.7	1.3	44.3	-	9.7	-	13.7	0.7	15.7	6.7	-	-	0.3	0.3	-	-	5.3
12.	18	-	1.7	0.3	19.0	-	5.7	0.7	14.7	1.3	21.7	22.3	0.7	0.3	-	0.3	1.0	2.7	7.7
13.	12	0.7	1.7	2.3	30.3	0.7	13.0	-	4.7	1.0	8.3	13.3	-	0.7	-	0.3	0.3	3.0	19.7
Mean =		0.49	2.63	1.59	32.29	0.22	10.34	0.23	11.60	0.62	10.57	12.47	0.10	0.61	0.13	0.51	0.79	3.07	11.67

Age Group 20 - 29 years

Case Number	Age in years	Myeloblast %	Pre-myelocyte %	Myelocyte		Young		Band		Polymorph		Lymphocyte %	Monocyte %	Turck %	Megakaryocyte %	Erythroblast Cells			
				% Eosinophile	% Neutrophile	% Eosinophile	% Neutrophile	% Eosinophile	% Neutrophile	% Eosinophile	% Neutrophile					Type I %	Type II %	Type III %	Type IV %
14	26	-	1.3	1.3	30.3	1.0	11.7	0.3	10.0	1.0	16.7	13.7	-	-	-	0.3	0.7	4.3	7.3
15	22	0.3	2.7	-	26.0	0.3	17.3	-	9.3	0.3	12.7	13.0	-	1.0	0.3	0.3	0.3	2.7	13.3
16	24	-	3.3	-	22.3	-	2.7	1.3	11.3	1.7	26.3	19.7	-	-	-	-	-	0.7	10.7
17.	23	0.3	2.7	0.3	27.0	-	5.7	1.0	9.7	1.0	20.3	23.7	-	-	-	-	0.3	0.7	7.3
18	20	0.3	2.0	1.7	29.0	0.7	16.0	0.3	11.3	2.3	9.7	10.7	-	0.7	-	-	1.3	2.7	11.3
19	22	2.0	4.0	1.3	22.7	1.0	22.7	0.3	10.7	1.0	3.0	12.7	0.3	-	1.0	0.3	2.0	5.0	10.0
20	28	1.0	3.0	1.0	42.3	-	7.0	0.3	11.0	0.3	9.0	8.3	0.3	0.7	-	0.7	1.3	8.0	5.7
21	26	-	4.0	0.7	34.0	0.3	12.3	-	7.7	0.7	10.3	15.7	-	0.3	-	0.3	0.7	2.3	10.7
22.	29	-	3.0	0.7	18.0	-	16.3	0.3	20.9	0.3	10.7	15.0	-	-	-	0.3	1.7	1.0	12.7
23	23	0.3	1.3	-	42.7	-	16.7	-	10.0	-	5.0	10.3	-	0.7	-	-	-	0.3	12.7
Mean =		0.42	2.73	0.70	29.43	0.33	12.84	0.38	11.10	0.86	12.37	14.28	0.06	0.34	0.13	0.22	0.83	2.77	10.17

Age Group 30 - 39 years

Case Number	Age in years	Myeloblast %	Pre-Myelocyte %	Myelocyte		Young		Band		Polymorph		Lymphocyte %	Monocyte %	Turck %	Megakaryocyte %	Erythroblast Cells			
				Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %					Type I %	Type II %	Type III %	Type IV %
24	32	0.3	2.7	0.3	34.0	0.7	18.3	0.3	9.7	-	7.7	9.7	-	0.3	0.3	0.3	-	6.3	9.0
25	32	0.3	1.3	0.3	23.3	-	11.0	-	13.0	0.3	18.3	15.0	-	0.3	0.3	0.3	0.7	7.0	8.3
26	31	-	1.0	0.3	26.3	-	9.0	-	15.0	0.3	15.0	15.3	-	0.7	-	0.3	0.3	3.3	13.0
27	34	-	2.3	0.3	31.7	-	8.0	-	8.3	0.3	9.3	12.3	-	0.3	-	0.3	2.0	2.3	22.3
28	35	-	2.3	0.7	36.0	-	7.0	0.3	10.7	0.3	13.3	9.0	-	-	-	-	0.3	2.0	18.0
29	38	1.3	6.0	2.0	36.0	-	10.7	-	10.0	0.7	10.0	15.3	-	1.0	-	-	-	1.0	6.0
30	36	-	2.7	1.3	29.7	-	6.7	0.7	10.7	1.3	20.3	18.7	-	0.3	-	0.3	0.3	-	7.0
31	34	0.7	1.3	0.7	27.7	0.3	6.7	0.3	11.3	1.0	16.3	13.3	-	0.3	-	0.3	1.7	4.7	13.3
32	31	0.3	1.7	2.0	25.0	1.3	13.0	1.3	25.0	0.7	7.7	7.0	-	-	-	0.3	1.3	6.3	9.0
33	31	-	2.0	1.3	28.7	-	9.3	0.7	20.0	1.3	13.0	11.7	-	0.7	-	0.3	0.7	5.0	5.3
Mean =		0.29	2.33	0.92	29.84	0.25	9.97	0.56	13.17	0.62	13.09	12.73	-	0.39	0.06	0.24	0.73	3.79	11.12

Age Group 40 - 49 years

Case Number	Age in years	Myeloblast %	Pre-myelocyte %	Myelocyte		Young		Band		Polymorph		Lymphocyte %	Monocyte %	Turck %	Megakaryocyte %	Erythroblast Cells			
				Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %					Type I %	Type II %	Type III %	%
34	43	1.0	3.7	0.3	26.7	-	5.0	-	7.0	1.0	28.3	22.3	0.3	-	-	-	0.3	1.0	3.0
35	47	0.3	1.3	-	22.0	0.3	11.3	0.3	13.3	0.3	20.0	18.7	-	0.3	-	0.7	1.3	0.7	9.0
36	41	1.0	2.3	-	35.0	-	8.7	-	7.7	0.3	17.7	9.3	-	0.3	-	0.7	0.7	9.0	7.3
37	49	0.3	3.0	-	18.7	-	3.0	0.3	8.0	1.0	25.3	24.7	-	-	-	-	1.3	5.3	9.0
38	44	0.7	4.0	0.7	17.0	-	8.0	-	6.7	0.7	35.3	9.0	-	0.3	-	0.3	1.0	1.0	15.3
39	42	0.3	1.7	1.0	35.3	-	7.0	-	9.7	0.3	11.3	12.0	-	1.0	-	0.3	1.0	9.3	9.7
40	49	1.0	4.0	0.3	19.3	0.3	5.7	-	13.0	1.0	25.0	18.3	0.3	0.3	-	-	0.3	4.7	6.3
41	42	-	3.0	0.3	26.3	-	12.7	-	14.0	-	18.7	10.3	-	0.3	-	-	-	1.0	13.3
42	45	1.3	3.7	1.0	29.7	0.3	11.3	0.3	7.3	0.3	12.3	5.7	-	0.7	-	0.7	1.7	5.7	18.0
43	46	-	2.3	0.3	19.7	-	13.0	-	14.0	0.7	16.7	15.0	-	-	-	-	1.3	2.3	14.7
Mean = 0.59			2.90	0.39	24.97	0.09	8.57	0.09	10.07	0.56	21.06	14.53	0.06	0.32	-	0.27	0.89	4.00	10.56

Age Group 50 - 59 years

Case Number	Age in years	Myeloblast %	Pre-myelocyte %	Myelocyte		Young		Band		Polymorph		Lymphocyte %	Monocyte %	Turck %	Megakaryocyte %	Erythroblast Cells			
				Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %					Type I %	Type II %	Type III %	Type %
44	51	0.3	1.7	0.3	22.0	-	7.0	-	15.3	0.3	21.3	14.7	0.3	1.0	-	-	0.3	3.3	12.0
45	59	0.3	2.0	1.0	28.3	0.3	8.7	0.7	10.0	-	10.0	9.7	-	1.0	-	1.0	2.3	4.0	20.7
46	53	0.3	3.0	0.3	35.7	1.0	8.7	0.3	13.7	0.3	16.7	11.0	-	-	-	0.3	0.7	0.7	7.3
47	54	-	2.0	1.0	24.0	-	12.0	-	11.7	1.0	15.7	17.0	-	1.0	-	0.3	0.7	6.3	7.3
48	52	0.3	0.7	0.3	47.7	-	8.0	-	8.3	-	16.0	8.0	-	0.3	-	-	0.3	2.0	8.0
49	54	0.3	3.7	1.7	31.7	-	9.0	0.3	14.0	-	18.3	11.7	-	-	-	-	0.3	4.0	5.0
50	56	0.3	2.7	-	29.0	0.3	10.7	0.3	17.0	0.7	3.0	12.7	-	0.3	-	1.7	2.0	7.0	12.3
51	56	0.7	1.7	2.0	25.7	0.3	8.7	0.7	11.7	1.0	9.0	12.7	-	1.3	-	2.3	1.7	9.3	11.3
52	50	0.3	1.3	0.3	38.7	0.3	14.3	1.0	10.7	0.3	12.3	9.0	0.3	1.0	-	0.3	-	2.3	7.3
53	52	0.3	2.3	0.7	32.3	-	6.0	0.3	11.0	0.7	17.7	14.0	0.3	1.0	-	-	1.0	1.7	10.7
Mean =		0.31	2.11	0.76	31.51	0.22	9.31	0.36	12.34	0.43	14.00	12.05	0.09	0.69	-	0.59	0.93	4.06	10.19

Age Group 60 - 69 years

Case Number	Age in years	Myeloblast %	Pre-myelocyte %	Myelocyte			Young		Band		Polymorph		Lymphocyte %	Monocyte %	Turck %	Megakaryocyte %	Erythroblast Cells			
				Eosinophile %	Neutrophile %	Basophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %					Type I %	Type II %	Type III %	Type IV %
54	67	-	1.7	-	13.0	-	-	4.0	-	14.7	0.3	34.0	14.0	-	-	-	0.3	1.3	0.7	16.0
55	66	0.7	2.7	1.7	29.3	-	-	6.3	1.3	16.7	1.3	15.0	6.0	-	0.7	-	0.3	0.3	6.0	11.7
56	66	0.7	1.3	-	31.3	-	-	8.0	-	10.3	0.3	16.3	14.3	-	1.0	-	0.7	1.7	2.3	11.7
57	67	0.7	2.7	0.7	27.0	-	-	19.3	-	10.3	0.3	14.7	11.7	0.3	0.7	-	-	0.7	4.0	7.0
58	63	0.7	2.7	0.3	29.3	-	-	12.3	0.3	13.0	1.0	9.3	6.0	0.3	2.0	-	0.3	1.0	8.3	13.0
59	65	0.3	4.7	0.3	18.3	-	-	10.7	0.3	26.0	0.3	9.7	16.7	-	-	-	-	1.7	5.0	6.0
60	66	-	1.3	0.3	29.3	0.3	-	4.7	0.7	14.7	0.7	18.3	11.3	-	-	-	0.3	-	7.0	11.0
61	62	1.3	4.0	-	30.7	-	0.3	9.7	0.3	14.3	-	10.0	8.3	-	0.3	-	0.3	1.0	3.3	16.0
62	66	-	1.3	-	33.3	-	-	6.7	0.3	21.0	-	19.0	7.3	-	0.7	-	-	0.3	3.0	7.0
63	62	0.3	1.3	-	28.3	-	-	4.3	-	10.7	0.3	19.0	14.7	-	-	-	-	1.0	7.3	12.7
Mean =		0.47	2.37	0.33	26.98	0.03	0.03	8.60	0.32	15.17	0.45	16.53	11.03	0.06	0.54	-	0.22	0.90	4.69	11.21

Age Group 70 - 79 years

Case Number	Age in years	Myeloblast %	Pre-myelocyte %	Myelocyte			Young		Band		Polymorph		Lymphocyte %	Monocyte %	Turck %	Megakaryocyte %	Erythroblast Cells			
				Eosinophile %	Neutrophile %	Basophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %					Type I %	Type II %	Type III %	Type IV %
64	72	0.3	2.0	0.3	30.7	-	-	5.3	-	9.3	1.0	17.7	15.7	-	0.3	-	0.3	0.3	1.0	15.7
65	70	1.0	2.0	1.3	30.3	-	0.3	8.3	0.3	16.0	0.3	16.7	8.0	1.0	0.3	-	1.7	0.7	5.7	6.0
66	74	0.7	2.3	0.7	15.3	-	0.3	9.0	-	19.0	0.3	16.0	16.0	-	2.0	-	2.0	-	2.3	14.0
67	71	1.7	3.7	1.0	30.3	-	0.3	5.7	-	8.0	1.3	16.0	3.7	-	1.0	-	1.0	4.0	8.0	14.3
68	78	-	2.0	1.3	20.7	0.3	-	8.7	1.0	14.0	1.0	19.0	15.3	0.3	0.7	-	1.0	0.7	0.7	13.3
69	78	0.3	2.0	-	25.0	-	-	5.0	-	11.7	1.0	23.3	16.7	0.3	-	-	-	-	1.0	13.7
70	71	0.7	2.3	1.0	20.3	-	-	15.7	-	22.3	-	9.7	12.3	-	1.3	0.3	0.7	1.7	4.0	7.7
71	78	-	1.3	-	28.3	-	-	9.3	-	14.3	-	7.7	8.3	-	0.3	-	1.0	2.3	2.7	24.3
72	73	0.7	1.7	0.7	33.7	-	0.3	7.0	1.0	12.0	1.0	5.7	12.0	-	1.3	-	1.7	0.7	6.0	14.7
73	79	1.0	2.7	-	23.3	-	0.3	8.7	0.3	12.7	-	9.7	14.0	-	0.3	-	1.7	1.7	14.0	9.7
Mean =		0.64	2.20	0.63	25.79	0.03	0.15	8.27	0.26	13.93	0.59	14.15	12.20	0.16	0.75	0.03	1.11	1.21	4.54	13.34

Age Group 80 - 99 years

Case Number	Age in years	Myeloblast %	Pre-myelocyte %	Myelocyte		Young		Band		Polymorph		Lymphocyte %	Monocyte %	Turck %	Megakaryocyte %	Erythroblast Cells			
				Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %	Eosinophile %	Neutrophile %					Type I %	Type II %	Type III %	Type IV %
74	80	0.3	2.0	0.3	24.0	0.7	9.7	0.7	14.3	1.0	9.3	6.7	-	-	-	0.3	0.3	1.7	28.7
75	80	-	0.7	0.7	24.7	-	6.7	0.7	13.3	-	14.3	7.7	-	0.3	0.3	0.3	1.3	9.0	20.0
76	84	-	1.7	0.3	20.7	0.3	7.7	-	13.0	0.7	17.7	14.0	0.3	0.7	-	1.0	1.0	4.0	17.0
77	81	-	1.3	-	34.7	-	7.7	0.3	10.3	0.3	4.3	3.7	-	-	-	0.3	0.7	6.0	30.3
78	86	0.3	2.0	1.3	33.7	1.0	11.7	0.7	16.3	-	8.0	5.7	-	0.3	-	0.3	-	2.3	16.3
79	93	1.0	2.0	1.3	26.3	0.3	9.3	-	12.3	0.7	7.3	9.3	-	-	-	0.3	2.0	12.0	15.7
80	82	0.3	2.7	-	37.0	-	10.0	-	13.0	-	11.7	12.7	0.3	0.3	0.3	-	-	0.3	11.3
81	90	-	1.0	-	38.7	-	7.3	0.3	11.3	-	11.3	8.0	-	0.7	-	-	-	2.0	19.3
82	91	1.0	2.7	-	26.7	-	8.3	-	8.7	0.3	11.0	11.7	-	0.7	-	1.3	1.7	6.7	19.3
83	80	-	0.3	-	37.0	-	6.7	-	9.7	0.7	21.3	16.7	-	-	0.7	-	-	0.7	6.3
Mean = 0.29			1.64	0.39	30.34	0.23	8.51	0.27	12.22	0.37	11.62	9.62	0.06	0.30	0.13	0.38	0.70	4.47	18.42

Percentages of the Various Types of Cell counted in the Complete Series of 83 Patients.

Type of Cell	Percentage of Total
Myeloblast	0.44
Pre-myelocyte	2.35
Myelocyte E	0.74
Myelocyte N	28.71
Basophile	0.01
Young E	0.20
Young N	9.65
Band E	0.30
Band N	12.47
Polymorph E	0.58
Polymorph N	13.92
Lymphocyte	12.69
Monocyte	0.08
Türck	0.49
Megakaryocyte	0.06
Erythroblast I	0.46
Erythroblast II	0.87
Erythroblast III	4.06
Erythroblast IV	11.90

COMPARISON OF VARIOUS AUTHORS' RESULTS

As has previously been stated, it is not always easy to compare the results of different authors on account of the wide and varied terminology used.

With regard to children, the following tables show the results published by Kato (1937), Diwany (1940) and Vogel and Bassen (1939) as 'normal' findings.

D I W A N Y

10 Normal children.

No.	Age		Sex	Total count	Neutrophile						Eosinophile				Monocyte	Lymphocyte	Erythnoblasts	Normoblasts	L/M Ratio
	Yrs	Mths			Myelo-blast	Premyelo-cyte	Myelo-cyte	Meta-myelocyte	Staff	Segmented	Myelo-cyte	Meta-myelocyte	Staff	Segmented					
1.	4	7	M	96,000	0.75	0.5	16.25	20.5	13	8	7.5	2	-	0.5	-	15	8	8	4.25
2.	4		M	82,000	2	-	25	28	4	7.5	2.5	-	-	0.75	-	12	13.5	5	4
3.	5	5	M	76,000	0.25	-	11	24.5	10	16	2.5	2	-	4	-	16	6	7	5.5
4.	4	4	M	140,000	0.25	-	13	22	13	17	4	-	-	2.5	0.4	20	3.75	4	9
5.	5	5	M	120,000	2	0.25	13	16	9	15	1.5	2.5	-	9	-	20.5	9	2.5	5.5
6.	4		F	96,000	1.5	-	9	22	14	10	5	0.5	-	2.5	3	22.5	7.5	2.5	6.75
7.	4	3	M	75,000	-	0.5	26	24	19	4	2	0.25	0.25	0.75	0.75	16.5	3	2	13
8.	4		M	160,000	0.75	0.25	7.5	17	16	12.5	5	3	-	1.25	-	22.25	11	3.5	4.2
9.	3	6	M	150,000	0.75	1.25	26	13.5	12	7	1.5	-	-	-	-	27	5.5	4	6
10.	4		M	120,000	0.50	2	24	15.5	10	8	2.5	-	-	1.5	-	27	6	4	6

K A T O

Age Period

	Months		Years				
	1-2	3-12	1-2	3-4	5-6	7-10	11-15
No. of cases	5	4	9	6	5	14	8
Myeloblasts	2	2	2	1	2	2	3
Myeloblastic leukoblast	4	2	3	3	5	2	4
Neutrophile Promyelocyte	5	6	9	8	10	4	4
Neutrophile Myelocyte	8	12	9	11	11	11	8
Neutrophile Metamyelocyte	9	17	11	10	13	11	10
Neutrophile Staff	10	8	16	12	13	19	21
Segmented	4	4	5	5	6	7	7
Eosinophile Myelocyte and Metamyelocyte	4	2	4	2	3	4	5
Eosinophile Staff and Segmented	3	1	2	2	1	2	2
Basophiles all stages	-	-	-	1	-	-	1
Monocytes	1	1	0	1	2	1	3
Lymphocytes	24	19	13	19	16	19	14
Erythroblasts	6	4	1	4	3	2	3
Normoblasts	20	22	25	21	15	16	15
M/E Ratio	1.9	2.1	2.3	2.4	3.7	3.4	3.6

VOGEL and BASSEN (1939)

Myeloblasts	1 - 5%
Myelocytes	10 - 25%
Non-segmented Neutrophiles	14 - 38%
Segmented Neutrophiles	6 - 34%
Lymphocytes	1 - 25%
Haematogones may be absent but in one case =	20%
Reticulum cells	0 - 0.5%
Megakaryocytes	0 - 0.5%
Megaloblasts	0 - 1.4%
Erythroblasts	0 - 15.4%
Normoblasts	2.5 - 37.5%

Present Series

(0 - 9 years)

Myeloblast		0.33
Premyelocyte		2.10
Myelocyte	Eosinophile	1.33
	Neutrophile	23.87
Young	Eosinophile	0.33
	Neutrophile	12.57
Band	Eosinophile	0.43
	Neutrophile	13.10
Polymorph	Eosinophile	0.90
	Neutrophile	7.10
Lymphocyte		21.67
Monocyte		0.10
Türck		0.23
Erythroblast	Type I	0.67
	Type II	0.67
	Type III	7.67
	Type IV	6.90

From the foregoing tables it will be seen that the present findings in children compare favourably with those of other workers.

Kato (1937) and Diwany (1940) both state that segmented cells are relatively low, that Myelocytes and Metamyelocytes form the largest percentage of Myeloid elements, and that there is a relatively high percentage of lymphocytes, particularly in infants.

Vogel and Bassen (1939) quote a higher segmented cell count (6 - 34%).

The Red cells show great variation. Diwany (1940) quotes 5 - 18.5%, the majority being erythroblasts.

Kato (1937) quotes 18 - 20%, mainly normoblasts.

The present work shows a low Normoblast count (6.9%), but the classification of Erythrogenetic cells differs from that of other workers.

The following tables show figures published by various authors on Normal Adult Bone Marrow investigations.

Certain workers express their findings as mean cell percentages, others quote the range of percentage findings in each cell type.

Results expressed as Averages

Cells		Harrison & Samwick %	R. B. Scott	Plum	Present Series	Stasney & Higgins	Holmes & Broun	Vogel, Erf, & Rosenthal	Reich	Segerdahl	Weiner & Kaznelson	Custer & Krumbhaar	Mallarmé	Wintrobe
Myeloblast		2	1.77	1.42	0.44	2.59	2.4	1.6	2.	1.3	4.6	0.6	2.5	2.
Pre-myelocyte			4.50	2.4	2.35	5.11		.1		1.5	5.	9.	1.5	5.
Myelocyte	E.	1	2.22		0.74			.77	20.	1.3	1.	2.	2.5	1.5
	N.	32	13.05	7.8	28.71	11.74	7	21.5		14.2	19.4	34.6	17.5	12
	B.		0.1		0.01						0.2			0.3
Meta-myelocyte	E.												0.5	
	N.	8		7.9		10.69					15.7	14.6	12	22.
	B.													
Young	E.				0.20			.39						
	N.		15.7		9.65		6.7	30.2	5.	14.8				
	B.													
Band	E.				0.30									
	N.	10	16.0	28.5	12.47		14		10.	8.3	6.3			
	B.													
Segmented	E.	1	1.5		0.58	4.19		.94		1.7	2.1		2	2.
	N.	46	14.75	8.7	13.92	7.06	17.4	34.	25.	22.3	22.3	3	32.5	20
	B.							0.07		0.2	0.8		0.04	0.2
Lymphocytes			10.85	6.3	12.69	6.02	24.9	8.6	10.	19.5	13.6		9.5	10

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Results expressed as Averages

Cells	Harrison & Samwick	R.B.Scott	Plum	Present Series	Stasney & Higgins	Holmes & Froun	Vogel, Erf & Rosenthal	Reich	Segerdahl	Weiner & Kaznelson	Custer & Krumbhaar	Mallarmé	Wintrobe
Monocytes		0.80	.77	0.08				1.	2.2	6.5			2.
Plasma		0.87		0.49	.46			1.	0.5	2.1		0.9	0.4
Megakaryocytes			.19	0.06	.22		.2			0.2	1.	0.06	0.4
Ferrata			.48										
Endothelial			1.		1.69		.25		.1	0.2	2.		0.2
Histiocytes											0.2		
Primitive cells						2.6							
Erythroblast				0.46			7.1	8.	12.3		14.8		
Pronormoblasts		0.43											4.
Basophilic Normoblasts		1.95		0.87									
Normoblasts (Polychromatic)		12.58		4.06									18.
Normoblasts (Orthochromatic)		2.73	26.42	11.90	45.62	6.9	22.6	15.		25.6	18.2	10.	
Mitotic normoblast		0.07											
Megaloblast						5.2	.14						
Haematogones							3.1						
Pro-erythroblast			2.61					2.				6.	
Polychromatic macroblasts			5.78										
Leukoblast					4.84								
Eosinophile myelocyte & segmented.						1.		1.					
Basophile myelocyte & segmented.						.3							
Monocyte & Reticulo Endothelial						9.						2.5	

Results expressed as Ranges of Cell Percentages

Cells	W. Damashek	J. Vaughan	Young & Osgood	Arinkin	Propp & Schwind	E. Osgood A. J. Seaman.	L. M. Weiner	Nordenson	Whitby & Britten	Piney
Myeloblast		0.25-5.5	0-1.2	0-2.4	0.4-2	0-2.4	0-4.5	0.25-5.5	0-2.5	1-2
Premyelocyte	1-5	0-8.25	Type I 0-4 / Type II 0-3.8	1-2.8	2.2-8	0-3		1.25-8.25	0.5-5.0	1-2
Myelocyte E.		0-6.25	0-0.4	0.3-1				0-6.25	0-1	1-2
Myelocyte N.	30-50	4.25-32.0	0-2.6	4.5-8.1	3.2-10.6	8-22.0	1.5-10.5	4.25-18	2-8	30-35
Myelocyte B.		0-0.5						0-0.5		
Meta-myelocyte E.			0-2	0.3-1					0-2.5	
Meta-myelocyte N.	20-40		1.8-9.8	1.4-3.4	5.6-14.2	8-23.0	6-20	12.5-42.5	2.5-12	10-15
Meta-myelocyte B.			-						-	
Young E.		0-1.6								
Young N.		2.25-42.5								
Young B.		0-1.5								
Band E.			0-1.6					-		
Band N.			15.8-33		17.6-46.4	6-12		2.25-10.75		
Band B.			0-0.6					-		
Segmented E.		0.2-7.5	0-1	0.6-4				0.25-7.5	0-4	0.5-1
Segmented N.	2-5	14.25-50	7.4-25.2	41-55	7.4-25	15-28	25-40	14.25-35.0	20-50	24-30
Segmented B.		0-1	0-0.2	0-0.7		7-30		0-0.75	0-1	
Lymphocytes		1-38.0	4.8-16	7.3-16.5		0-4	1.5-9.5	7.5-38	5-20	14-21

contd. on next page.

Results expressed as Ranges of Cell Percentages.

Cells	W. Damashek	J. Vaughan	Young & Osgood	Arinkin	Propp & Schwind	E.Osgood A.J. Seaman	L.M. Weiner	Norden-son	Whitby & Britten	Piney
Monocytes		0-5	0-4.2					0-5	0-5	
Plasma		0-3.25	0-1					0 -3.25	0-1	½-1
Unclassified		0-10.6						0-4.5		
Megakaryocytes		0-1		0.6 - 6.1			About 1.5	0-1		Always Present
Ferrata								3-40		½-½
Endothelial				2.1- 9.3						
Histiocytes	1-2									
Türck				0.3- 0.9						
Erythroblast	20	0- 0.5		5.7- 16		3-21	8.5- 27.5			
Pronormoblasts					0.4- 1.4			0-6		1-2
Basophilic Normoblasts					0.6- 3.2			1-16	)	
Normoblasts (Polychromatic)					2.6- 17.6				) 4-15	
Normoblasts (orthochromatic)					0.4- 4.8			26- 184	7-19	15-20
Megaloblast		0-25.	0-4.2				0.5- 2.5			2-3
Pro-erythroblast				0.8- 2.9					0-4	
Leukoblast					0.4-3					
Normoblast (unspecified)	80	5-60	5.4-20							
Eosinophiles	1-5				0.6-5.5	1-5				
Haemocytoblast		0-1.4							0-1	
Disintegrated		12.8-31.8								
Reticulum							0-0.8			
Indeterminate Blasts										0-1
Macronormoblast										0-1

Most authors quote a slightly higher Myeoblast count but the present findings agree closely with those of Custer and Krumbaar (1935) who quote a Myeloblast count of 0.6%.

Custer and Krumbaar quote a high pre-myelocyte count (9%).

Vogel, Erf and Rosenthal (1937) quote a much higher percentage of Young cells but the term "Young cell" is used by them to include Metamyelocytes and Band forms.

Plum (1941) quotes a high Band cell count.

Mallarmé (1939) and Vogel, Erf and Rosenthal (1937) quote a higher percentage of segmented cells.

The present investigation agrees with the findings of Scott (1939) who quotes a Polymorph count of 14.75%.

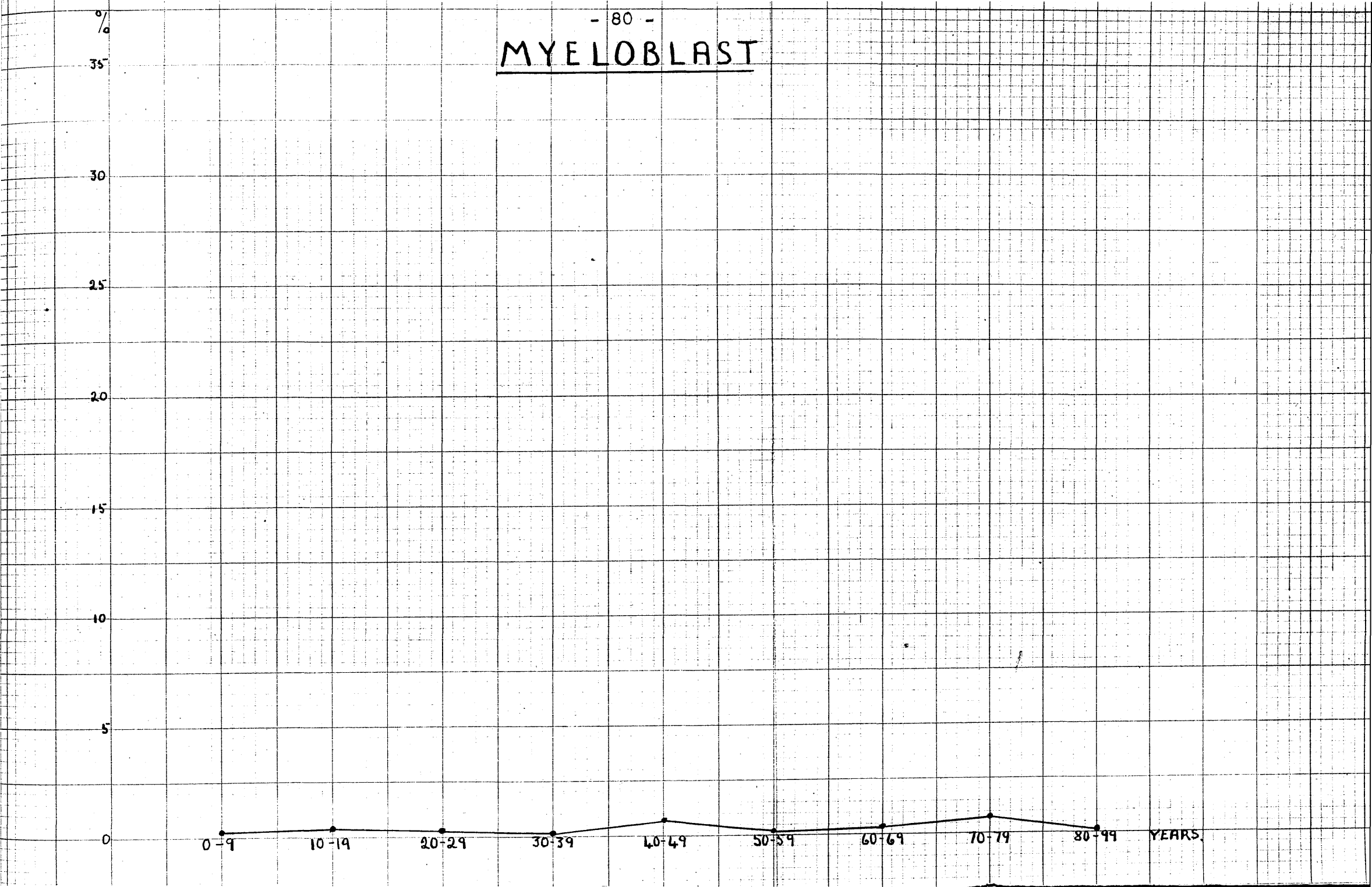
Holmes and Broun (1932) quote a higher percentage of Lymphocytes (24.9%) than most other workers.

Although the limits of normality for each cell type vary widely, the present findings agree favourably with those of other workers.

It is the purpose of the present investigation to study the relationship of the mean cell percentages to age.

For this purpose the mean percentages for each age-group have been plotted on graphs.

MYELOBLAST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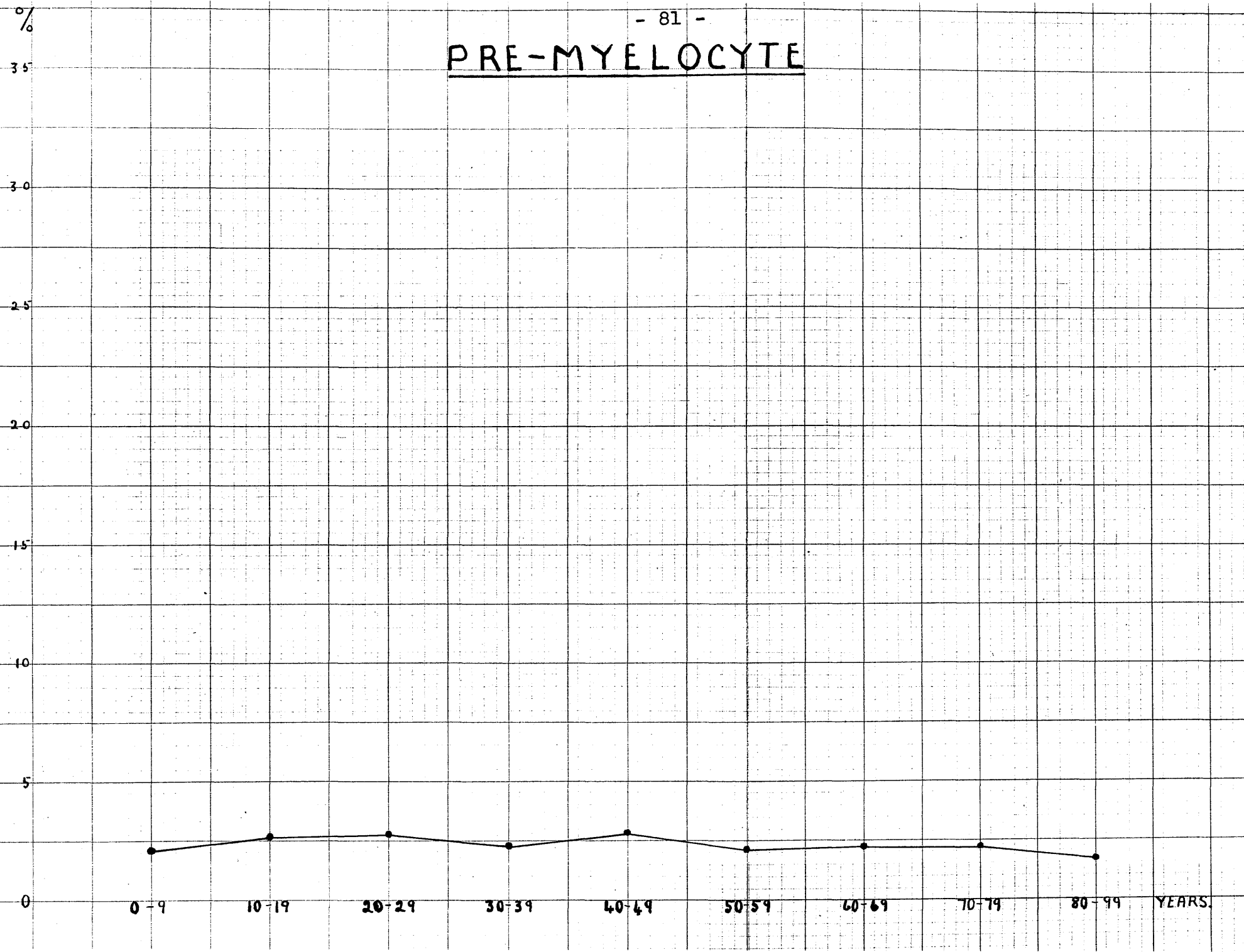
70-79
80-99
YEARS.

PRE-MYELOCYTE



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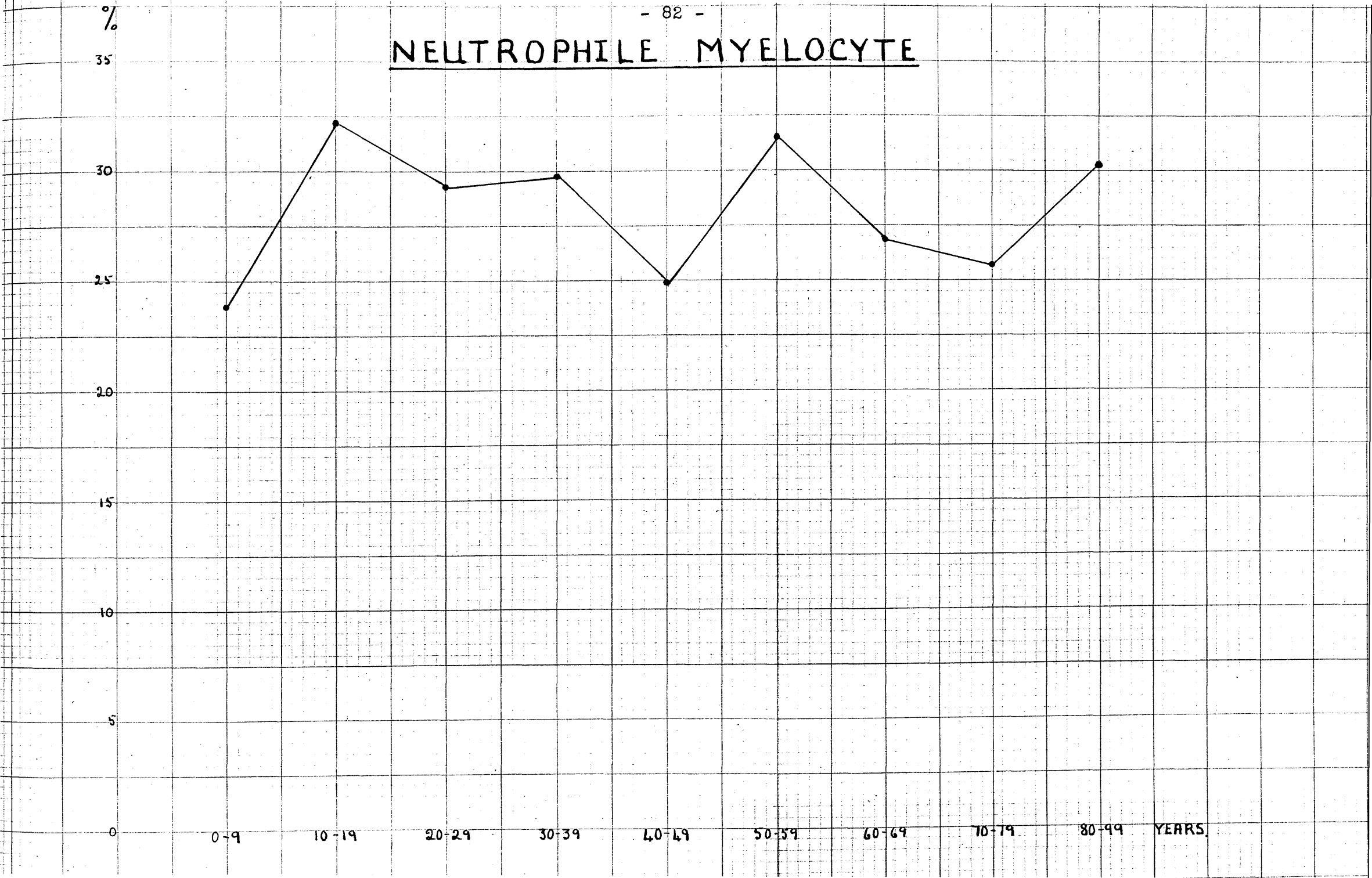

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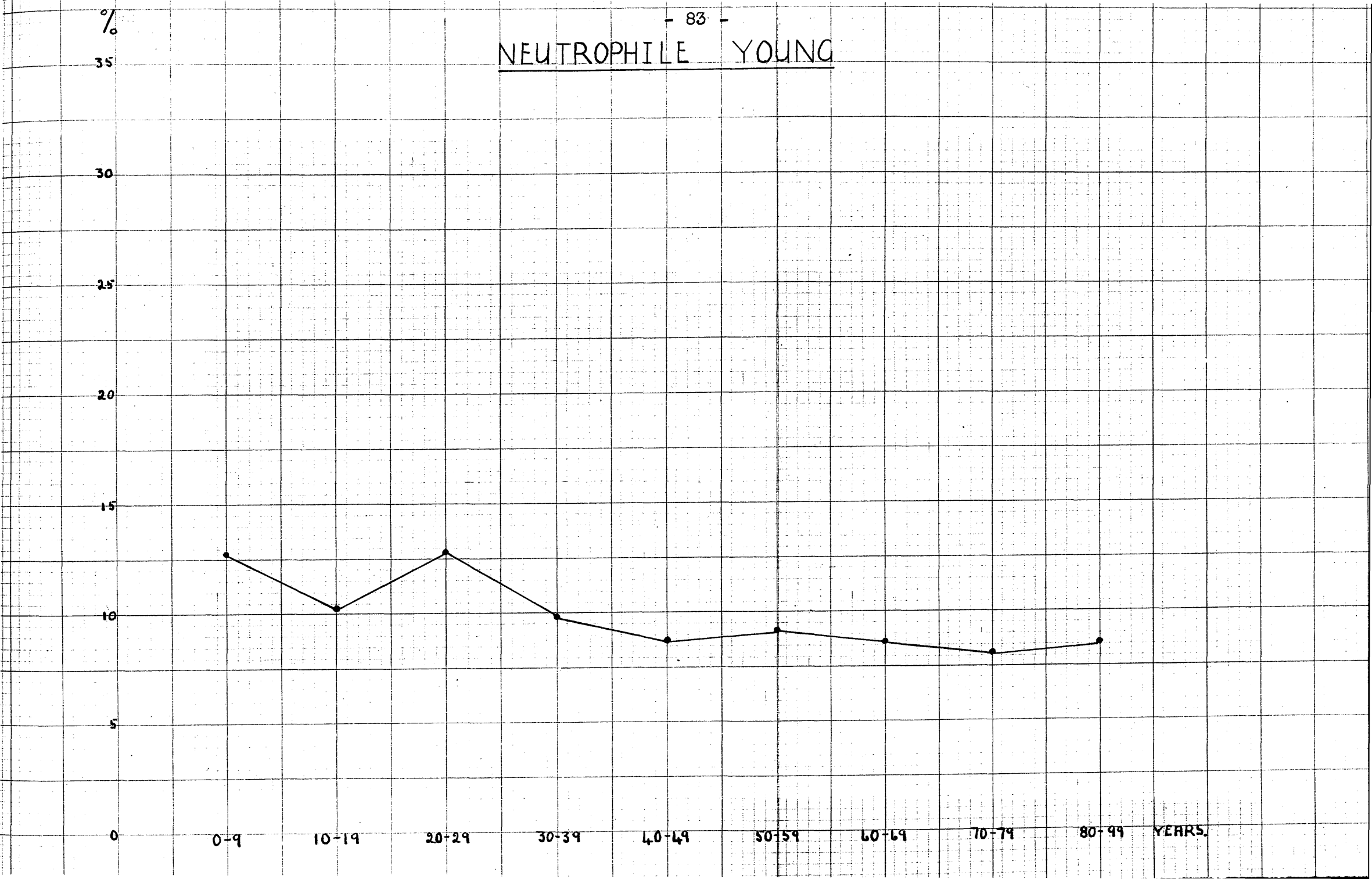

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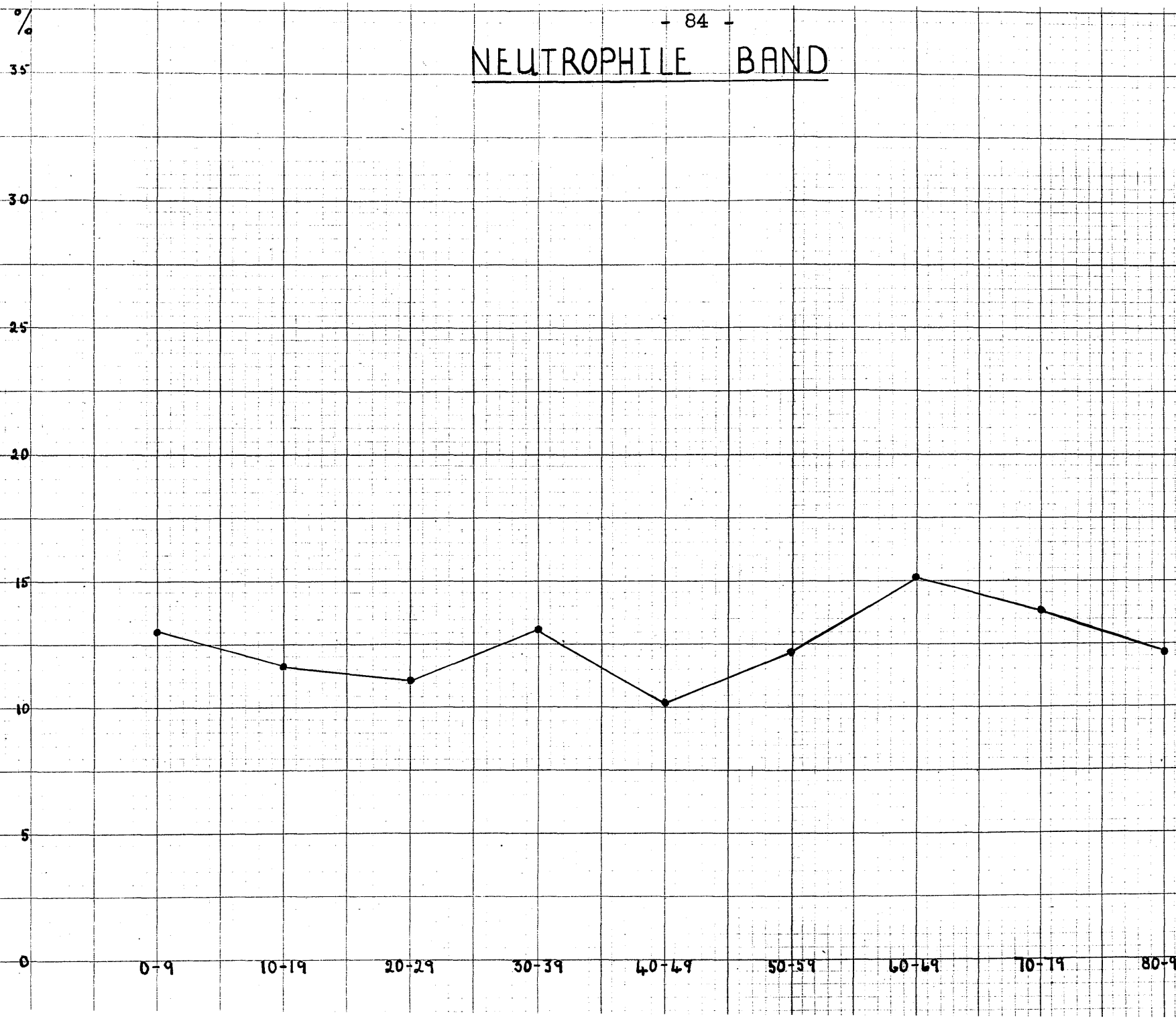
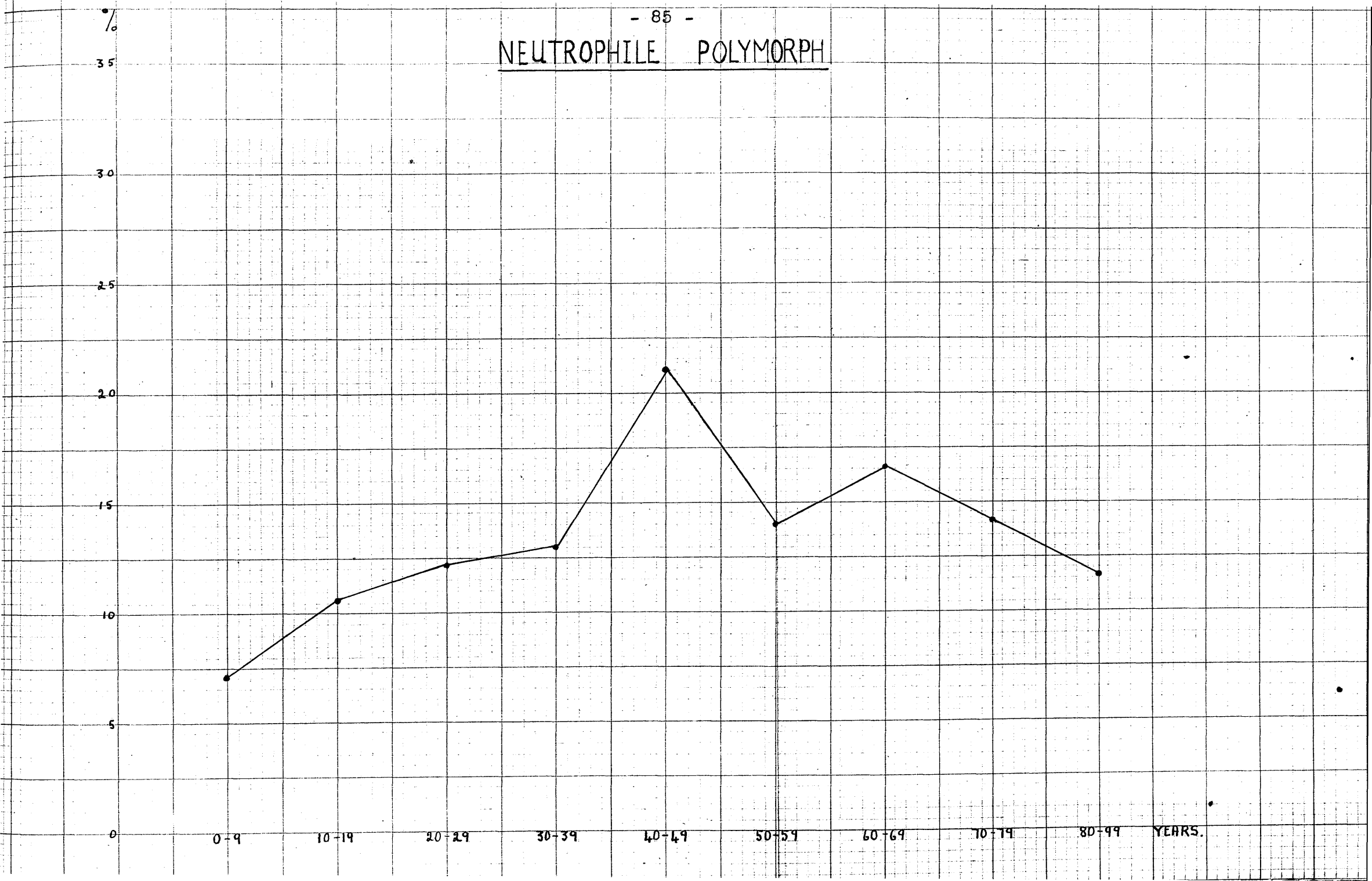
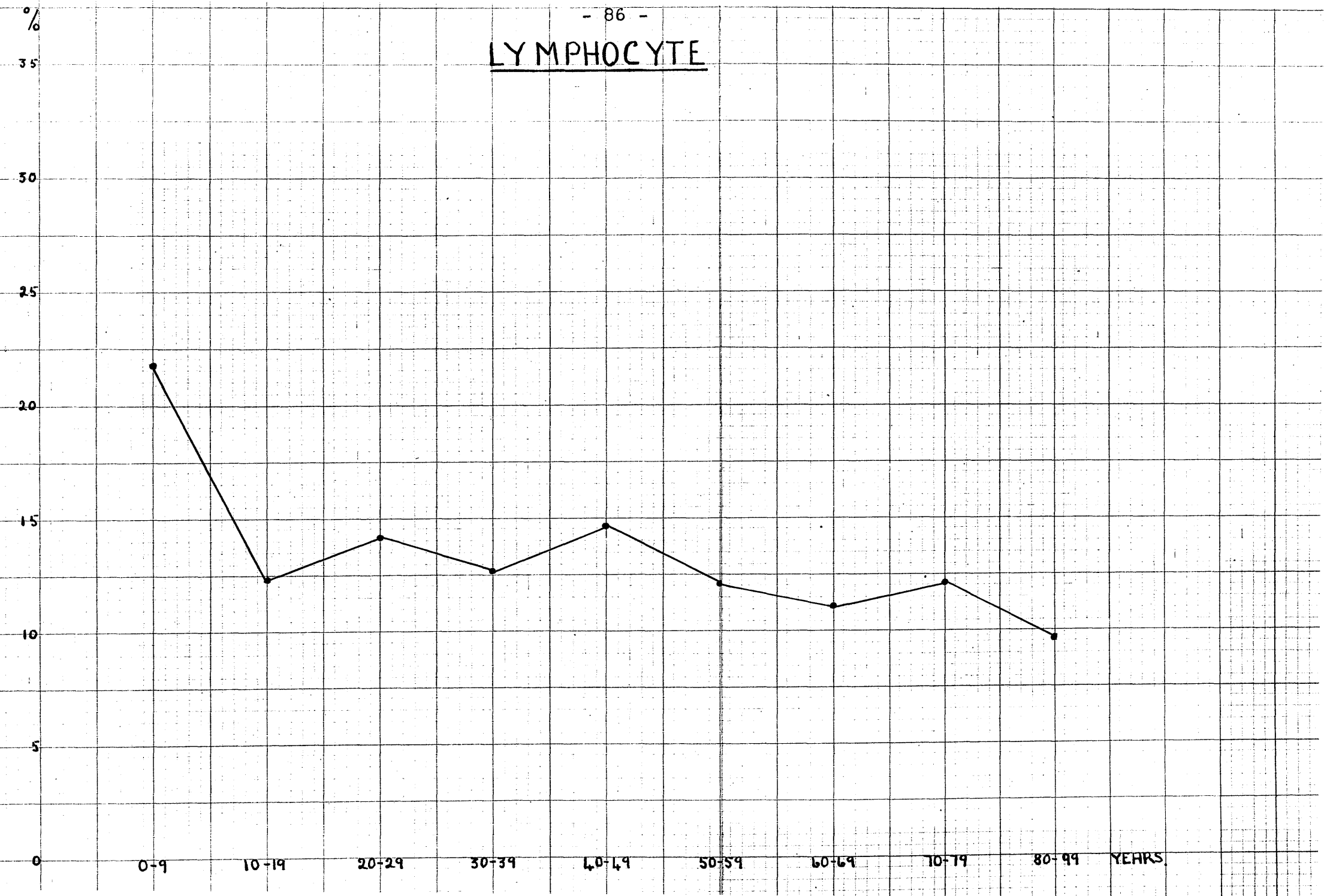


NEUTROPHILE POLYMORPH



LYMPHOCYTE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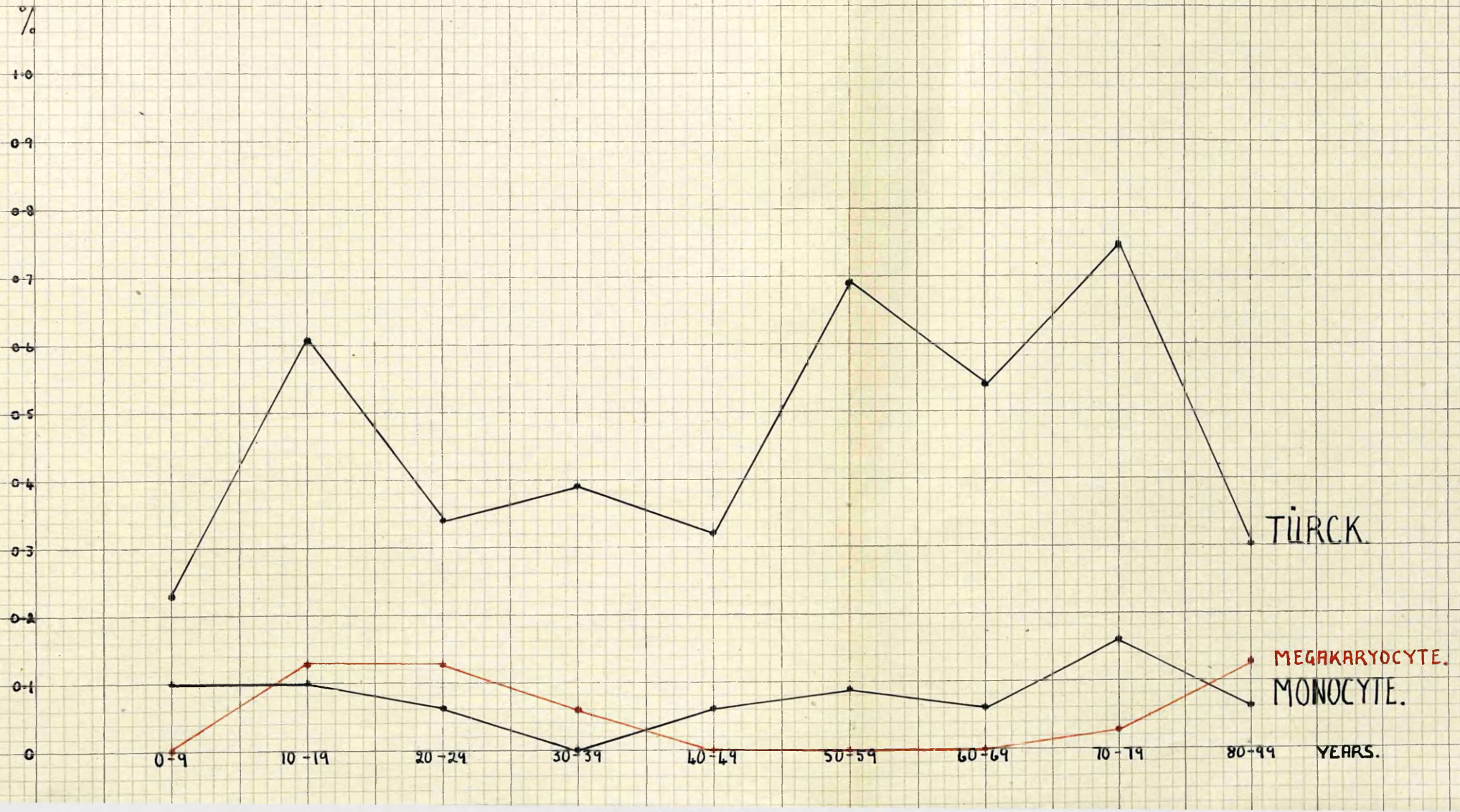
80-99
YEARS.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30-39
40-49
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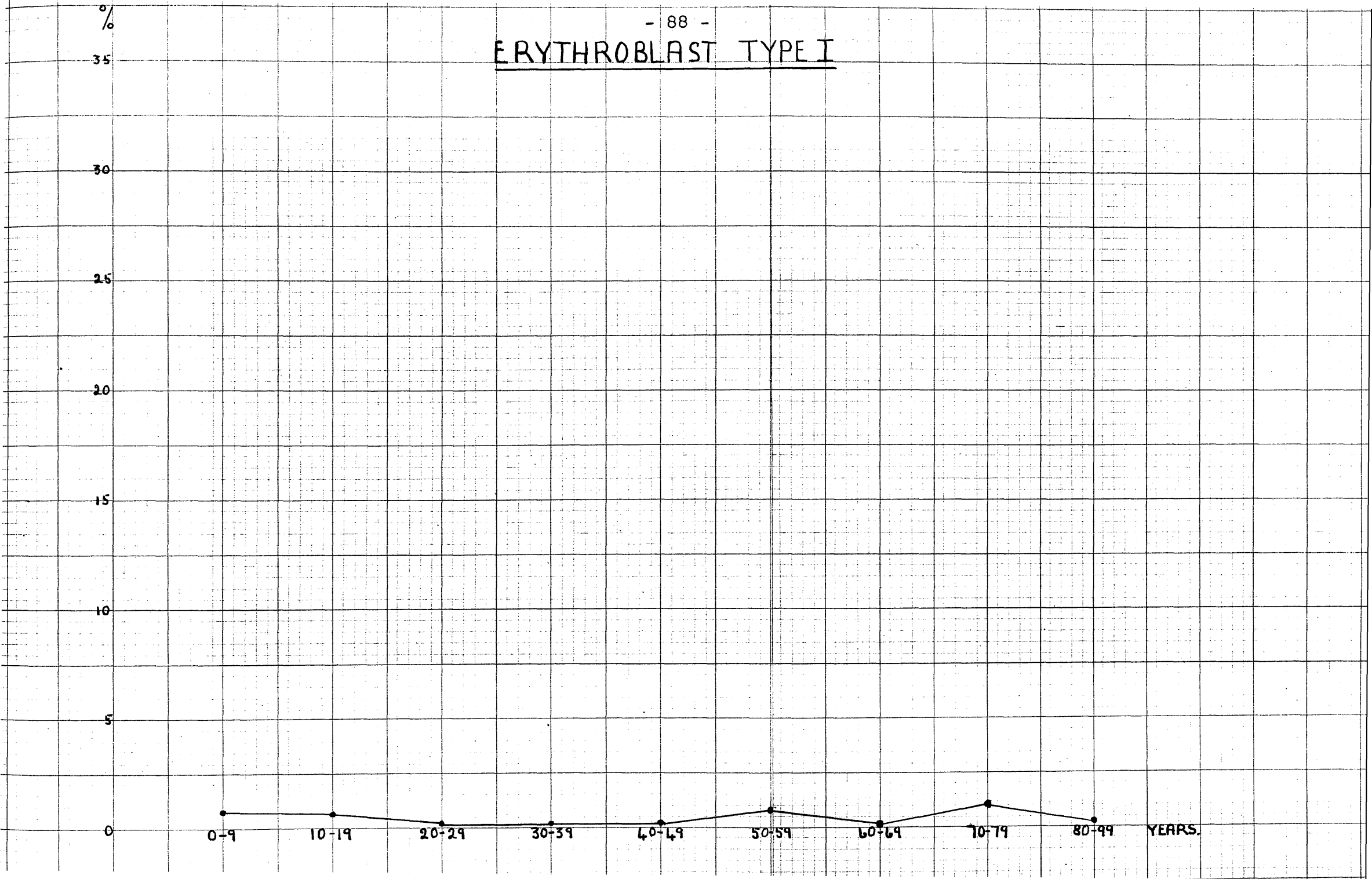
70-79
80-99
YEARS.
TÜRCK.
MEGAKARYOCYTE.
MONOCYTE.

ERYTHROBLAST TYPE I



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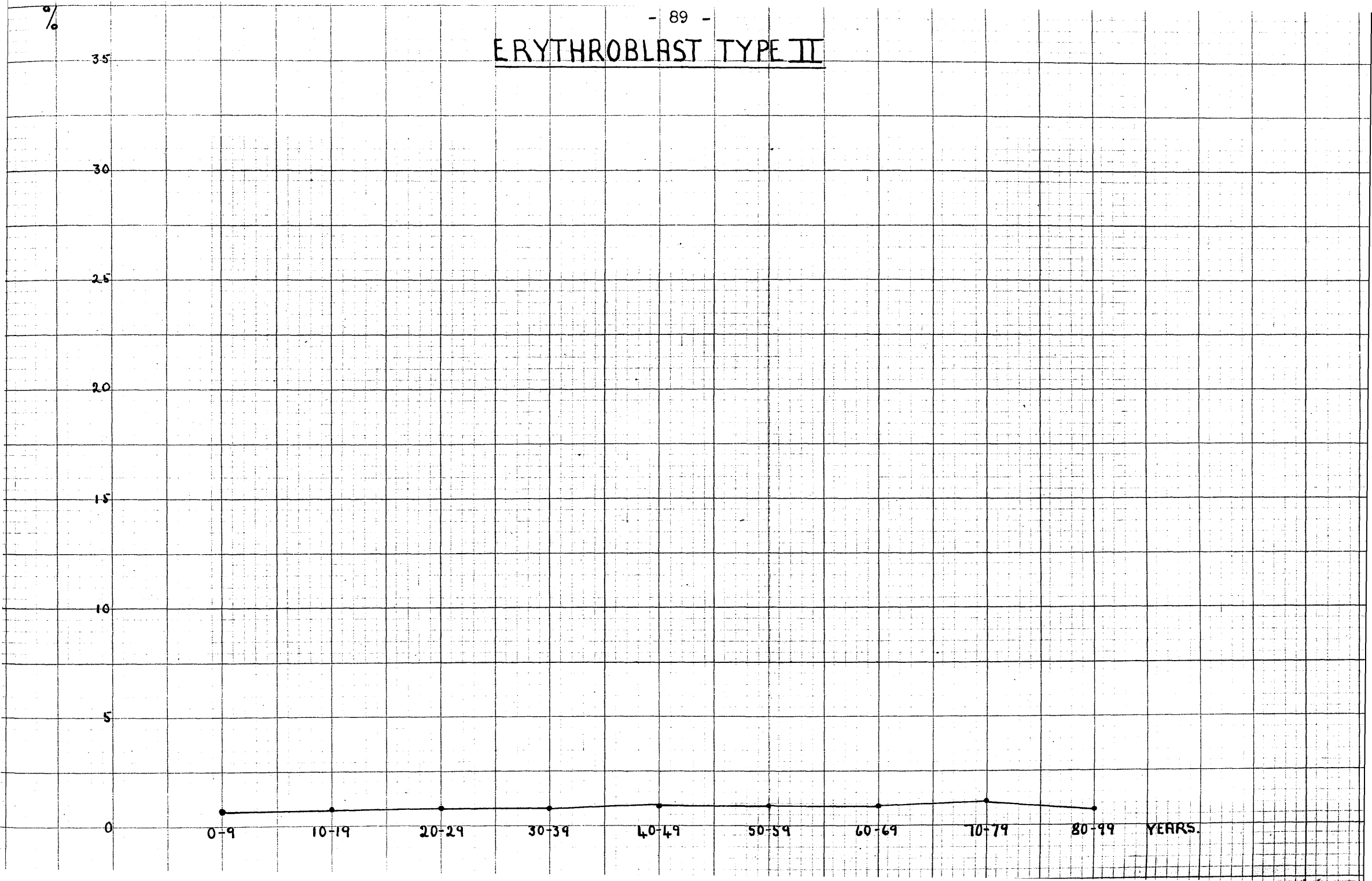

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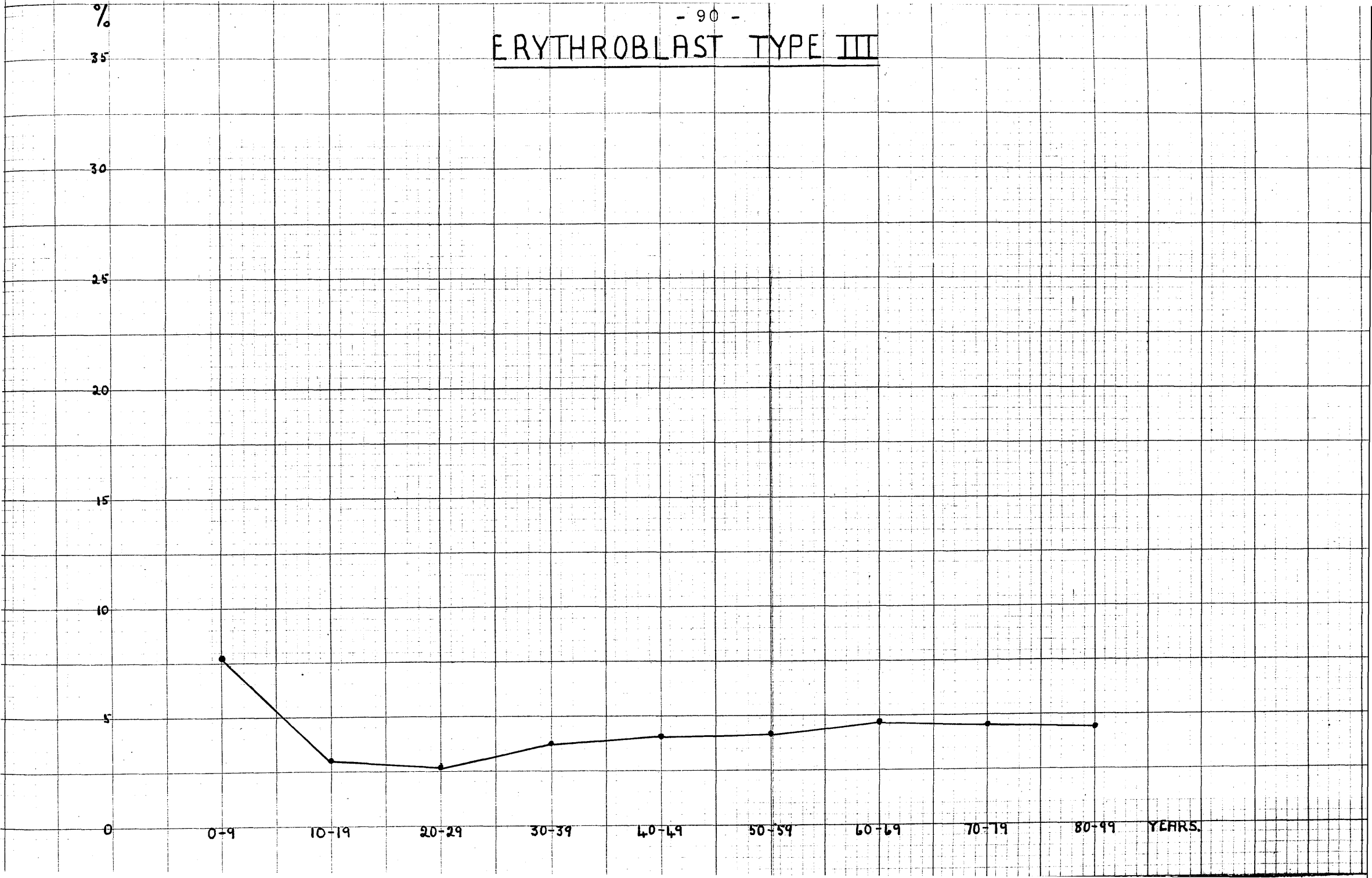
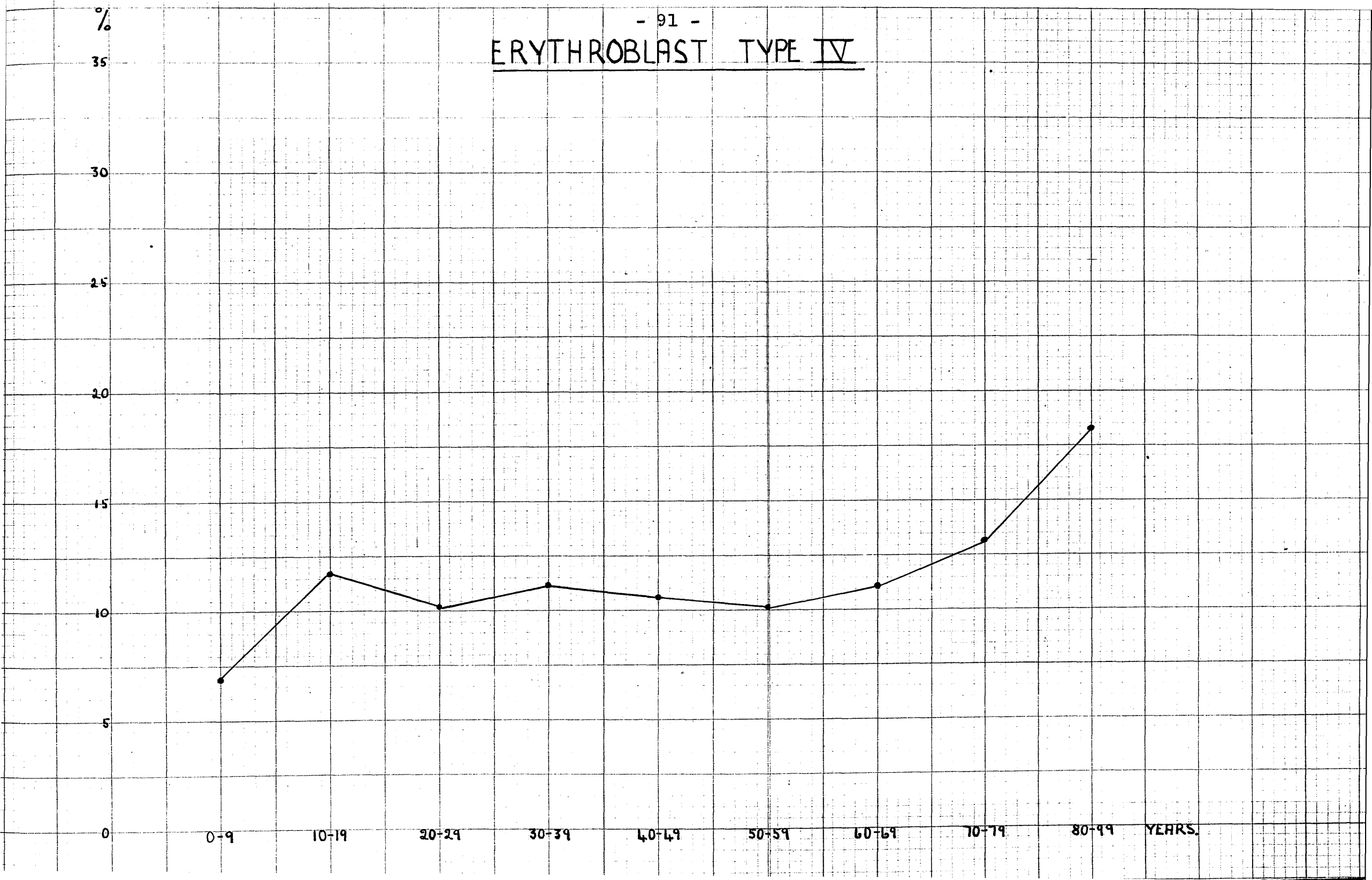


ERYTHROBLAST TYPE IV



MEAN CELL PERCENTAGES WITH STANDARD ERRORS BY AGE.

The following table shows the average percentages of certain cell types counted, with their standard errors, in the nine age-groups.

Standard errors were calculated in those cell types which appeared to have any significant change with age, namely:- Young (Neutrophile), Polymorph (Neutrophile), Lymphocyte and Erythroblast Type IV.

The standard error provides a measure of the chance fluctuation that may be expected in the mean. It may be asserted with a fair degree of confidence (allowing 1 chance in 20 of being wrong) that the true mean percentage lies in the range "observed mean plus or minus twice the standard error".

To determine if any importance should be attached to apparent changes with age, regions of acceptability for the mean ($\pm$ 2.S.D.) have been plotted on the graphs of the mean percentages for each age-group.

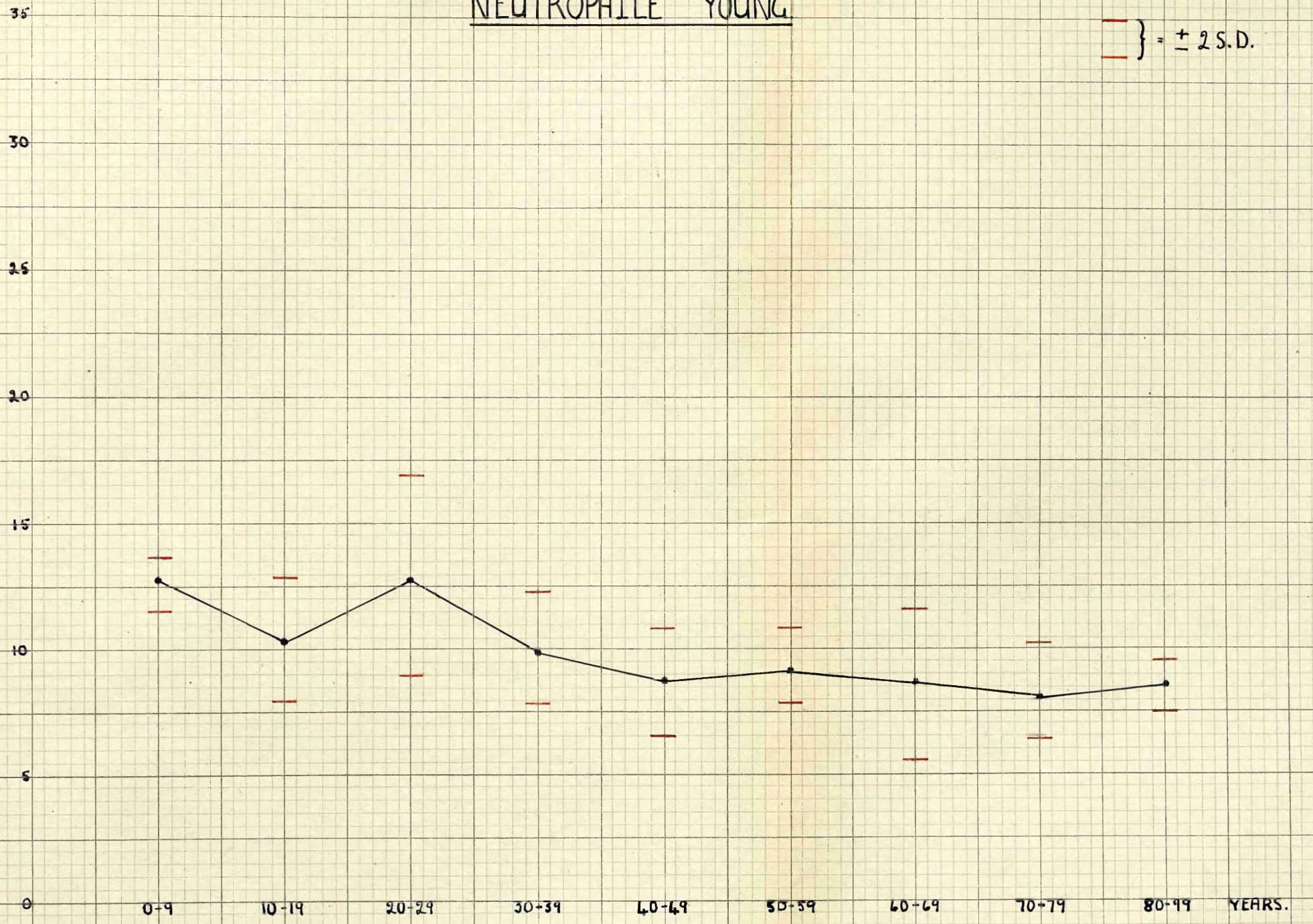
If a horizontal line can be drawn which passes through all the regions of acceptability, there is no evidence of any age change.

TABLE 2

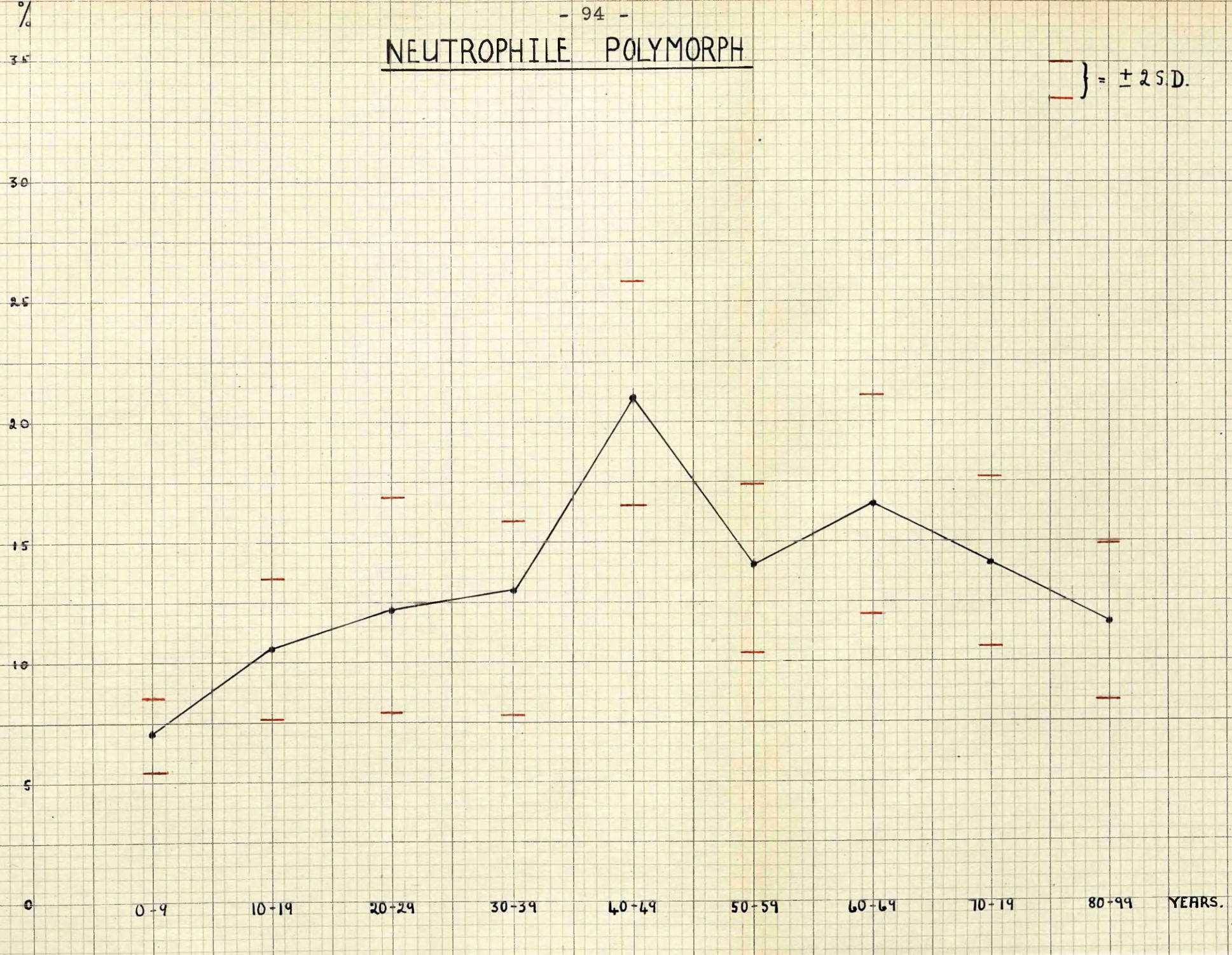
Mean cell percentages with standard errors, by age.

Cell-type / Age in years	Young (Neutrophile)		Polymorph (Neutrophile)		Lymphocyte		Erythroblast Type IV	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
0-9	12.6	± 0.5	7.1	± 0.8	21.7	± 1.3	6.9	± 1.2
10-19	10.3	± 1.2	10.6	± 1.5	12.5	± 1.7	11.7	± 1.7
20-29	12.8	± 2.0	12.4	± 2.2	14.3	± 1.4	10.2	± 0.8
30-39	10.0	± 1.1	13.1	± 1.4	12.7	± 1.1	11.1	± 1.7
40-49	8.6	± 1.1	21.1	± 2.4	14.5	± 2.0	10.6	± 1.5
50-59	9.3	± 0.8	14.0	± 1.7	12.0	± 0.9	10.2	± 1.4
60-69	8.6	± 1.5	16.5	± 2.3	11.0	± 1.2	11.2	± 1.1
70-79	8.3	± 1.0	14.1	± 1.8	12.2	± 1.4	13.3	± 1.6
80-99	8.5	± 0.5	11.6	± 1.6	9.6	± 1.3	18.4	± 2.3

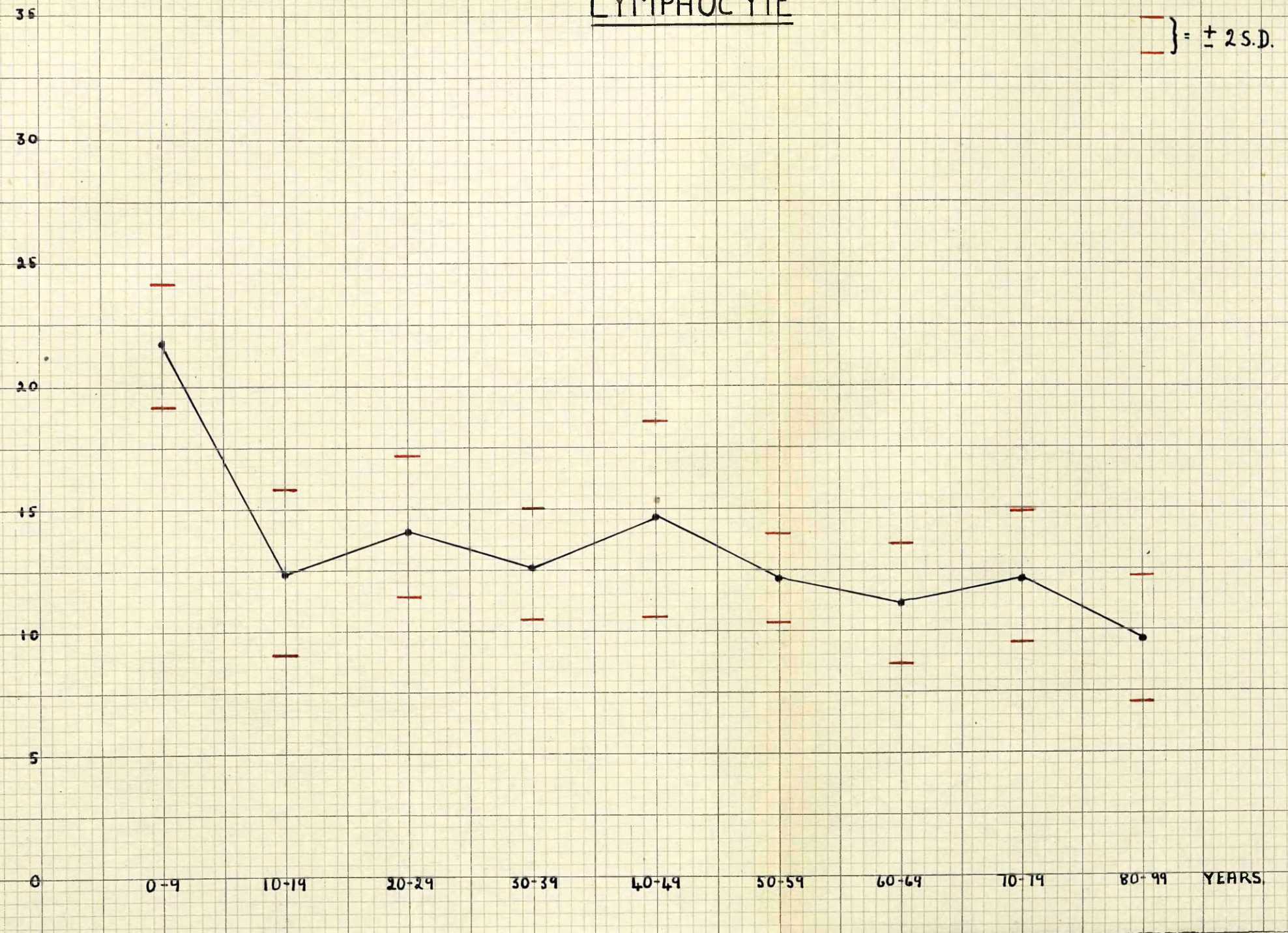
NEUTROPHILE YOUNG



NEUTROPHILE POLYMORPH



LYMPHOCYTE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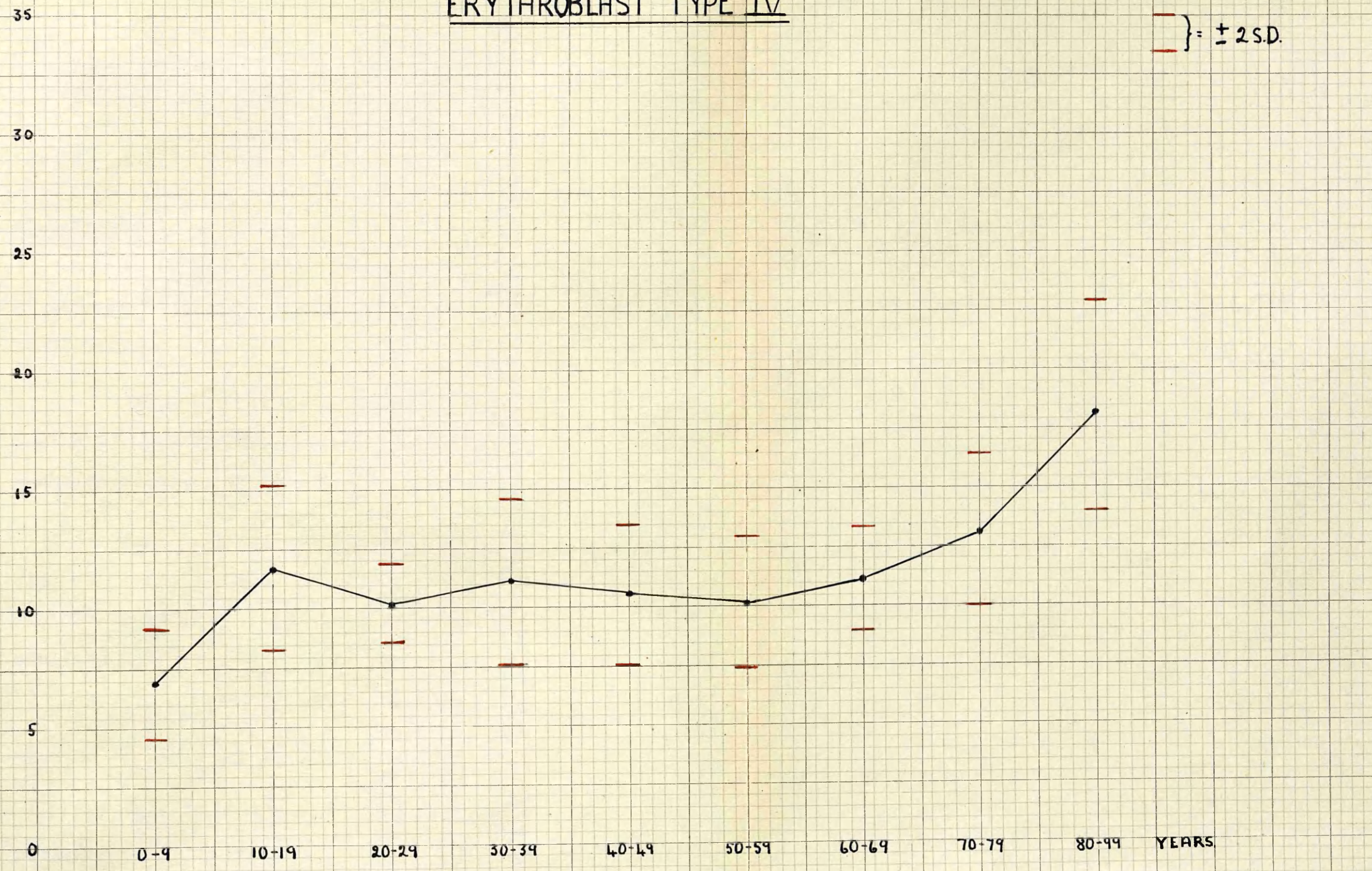
80-99
YEARS

ERYTHROBLAST TYPE IV



VARIATION IN MEAN CELL PERCENTAGES WITH AGE.

ANALYSIS OF GRAPHS.

Myeloblasts.

There is a slight increase in the number of cells in the age group 40-49 years, and a similar increase at 70-79 years.

There is, however, no significant change in the number of Myeloblasts present in normal bone marrow between the groups from 0-99 years.

This is in agreement with Nordenson (1935) who states that the highest number of Myeloblasts are present at 74 years, but that a child of 6 years has no more Myeloblasts than an adult of 84 years.

Jacobsen (1941) states that the Myeloblast cells show no variation in number with age.

Osgood and Seaman (1944) find a slightly higher percentage of Myeloblasts in children than in adults.

Pre-Myelocyte.

There is a slight increase in the number of Pre-myelocyte cells present at 40 - 49 years, but no significant change in the mean cell percentages of the age groups ranging from 0 --99 years.

This is in agreement with Jacobsen (1941) who finds no change in the mean cell percentages in the different age groups.

Osgood and Seaman (1944) find a slightly higher percentage of Pre-myelocyte cells in children than in adults.

Myelocyte (Neutrophile).

The mean cell percentages show great variability with age. The maximum increase is to be found in the age-group 10 - 19 years and the lowest figure is reached in the age group 40 - 49 years.

Although the number of cells steadily decreases between the age-groups 50 - 59 years and 70 - 79 years, it is interesting to note that it rises sharply again between 80 - 99 years.

These findings do not correspond with the findings of

Jacobsen (1941) who finds 25% of cells at 7 years dropping to 17.5% at 24 years, rising to 20.5% at 45 years and falling to 20% at 82 years.

Segerdahl (1935) states that in old people the mean value of Myelocyte cells is definitely lower than in young people.

Young (Neutrophile) Cells.

The means show a tendency to decrease with age.

To determine if any importance should be attached to this apparent change with age, regions of acceptibility for the mean - plus or minus twice the standard error (Lyons 1942) - have been plotted on the graph of the mean dell percentages. A horizontal line may be drawn passing through all regions except the first, and in this age-group only three cases were examined.

Owing to the small number of cases examined, it cannot therefore be concluded that there is any definite age-change, although in all probability a higher number of cells is present in young people than in old people.

This is in agreement with Segerdahl (1935) who states that the mean value of Metamyelocyte cells is definitely lower in old people than in young people.

The findings do not correspond with those of Jacobsen (1941) who states that 25% of Metamyelocyte cells are present at 7 years, rising to 22% at 8 years, falling to 18% at 13 years and 17% at 24 years, gradually rising to 21% at 81 years.

Band (Neutrophile).

The means show no significant change with age, approximately the same number of cells being present in the age groups 0 - 9 years and 80 - 99 years.

The lowest mean-cell percentage is found in the age-groups 40 - 49 years, and the highest mean cell percentage in the age-group 60 - 69 years.

These findings do not correspond with those of Jacobsen (1941) who finds 7% Band cells at 7 years gradually rising to 16% at 35 years, falling sharply to 12% at 45 years and gradually falling to 11% at 81 years.

Segerdahl (1935) states that the mean value of Stab cells in old people is definitely lower than in young people.

Polymorph (Neutrophile)

The mean percentage of cells shows a marked relation with age, rising from 7% in the age-group 0 - 9 years, to a maximum of 24% in the age-group 40 - 49 years, thereafter declining to 11.5% in the age-group 80 - 99 years.

The graph confirms the significance of this change.

These findings correspond with those of Jacobsen (1941) in that he finds 7% segmented cells at 7 years, with a maximum rise of 16% at 35 years, thereafter declining to 11% at 81 years.

Osgood and Seaman (1944) state that a slightly lower Polymorph count is present in children than in adults.

Monocyte.

Cells are scanty in marrow films and the mean cell percentages show no significant variation with age. There is a rise from 0% at 30 - 39 years to 0.16% at 70 - 79 years.

Jacobsen (1941) states that a rise from 1% at 7 years to 1.5% at 35 years is to be found.

Lymphocyte.

The mean-cell percentage shows little variation between the ages of 10 and 99 years.

The percentage at 0 - 9 years is considerably higher, and it is much greater than in any subsequent age-group.

It seems that the percentage dropsto a fairly stable level by the age of 10 years.

The high lymphocyte count in children is in agreement with the findings of Kato (1937) and Diwany (1940).

Jacobsen (1941) also finds a high mean cell percentage of 22% at 7 years, falling steeply to 12% at 13 years, rising to 15.8% at 18 years and gradually falling to 12% at 81 years.

Segerdahl (1935) reports an increase of lymphocyte cells in old people compared with young people.

Türck Cells.

The means show no significant change with age, the maximum rise being found at 70 - 79 years.

Megakaryocyte.

The means show no significant change with age, Meyakaryocyte cells being infrequently found.

ERYTHROBLAST SERIES.

Type I.

Beyond a slight increase at 70 - 79 years, the mean cell percentages show no significant variability with age,

This is in agreement with the findings of Jacobsen (1941) who states that 1% Proerythroblast cells are present at all ages.

Type II.

The mean cell percentages show no variation with age.

Type III.

There is a slight increase in the mean cell percentages in children, thereafter a stable level is reached at 10 years.

Type IV.

The mean cell percentage rises from 7% at 0 - 9 years to 11.5% at 10 - 19 years. There is a steady rise after the age of 60 years, the highest number of cells being present at 80 - 99 years.

The graph indicates that this is probably a real effect as a horizontal line drawn through the first seven age-groups does not include the last two.

Jacobsen (1941) finds 7.5% cells at 7 years rising to 13% at 18 years and 14% at 40 years, thereafter falling to 12% at 81 years.

Plum (1941) examined 40 cases from 18-68 years (18 men and 22 women) and states that he finds a slight depression of Erythropoiesis with the lowest point at 50 years.

The following Table shows the maturity dispersions and Leuko - Erythrogenetic ratio by age.

TABLE I

Maturity Dispersions and Leuko-erythrogenetic Ratio, by age.

Age in Years	Group A					Group B				Leuko-erythrogenetic Ratio
	No. of cells counted in Group A	Cell-type				No. of cells counted in Group B	Cell-type			
		Myeloblast	Pre-myelocyte	Myelocyte	Young		Erythroblast I	Erythroblast II	Erythroblast III, IV.	
0-9	365	0.8	5.2	62.2	31.8	143	4.2	4.2	91.6	2.55
10-19	1428	1.1	5.5	71.2	22.2	482	3.3	5.0	91.7	2.96
20-29	1394	0.9	5.9	64.8	28.3	420	1.7	6.0	92.4	3.32
30-39	1308	0.7	5.4	70.6	23.4	478	1.7	4.6	93.7	2.74
40-49	1126	1.6	7.7	67.6	23.1	472	1.7	5.7	92.6	2.39
50-59	1327	0.8	4.7	72.9	21.6	474	3.8	5.9	90.3	2.80
60-69	1164	1.2	6.1	70.4	22.3	511	1.4	5.3	93.3	2.28
70-79	1131	1.7	5.8	70.1	22.4	605	5.5	6.0	88.6	1.87
80-99	1242	0.7	3.9	74.2	21.1	720	1.7	2.9	95.4	1.72
All ages	10,485	1.0	5.6	70.0	23.4	4,305	2.7	5.0	92.3	2.44

Leuko-erythrogenetic Ratio.

At all ages 10,485 cells of Group A types were counted.

Of these 1.0% were Myeloblast, 5.6% Pre-myelocyte, 70.0% Myelocyte and 23.4% Young cells.

In the Erythroblast series 4,305 cells were counted. Of these 2.7% were Type I, 5.0% Type II and 92.3% Type III and Type IV.

The Leuko-erythrogenetic ratio equals $\frac{10,485}{4,305}$ or 2.44.

From the Table it will be seen that the Leuko-erythrogenetic ratio shows a tendency to decline with advancing age. Under 35 years the ratio is above the average of 2.44 and after the age of 60 years it is below this average.

Scott (1939) quotes a normal Leuko-Erythrogenetic ratio of 1.97.

MATURITY DISPERSIONS

Granulopoietic Cells.

On examining the maturity dispersions in Group A for individual age groups, it is seen that there is no evidence of any important change with age.

At ages 0 - 9 years there is an excess of Young cells relative to the other three types, but in view of the fact that only three cases were examined in this age group, little weight can be attached to this finding.

Erythropoietic Cells.

The maturity dispersions in Group B show no significant change with age.

CONCLUSION

The result of the present investigation has been to show that the majority of cell elements in the normal bone marrow show no significant quantitative change with age.

The mean cell percentage of Polymorph (Neutrophile) cells shows a maximum rise at 40-49 years.

That of the Lymphocyte cells shows a rise at 0-9 years reaching a stable level at 10 years.

The mean cell percentage of Erythroblast type IV cells shows a steady rise after the age of 60 years.

The latter finding is in contradiction to the findings of Segerdahl (1935) who states that there is a falling level of all specific elements in the bone marrow of old people due to an increase of fat in the marrow.

In the present work the mean percentage rise of Erythroblast Type IV cells in old people is shown to be statistically significant. It is also shown that there is an actual increase in Myelocyte (Neutrophile) cells between the age-groups 70-79 years and 80-99 years, but the graph does not confirm that this rise has any statistical significance.

It is also shown that the bone marrow of children contains fewer mature Erythroblast cells and Polymorph cells than that of adults. This is in agreement with Jacobsen (1941) who states that the bone marrow in children is immature and contains fewer Erythropoietic and mature Neutrophile cells.

C.M. Plum (1941) states that there is no relation between age and percentage distribution of bone marrow cells in individuals from 18-68 years.

The present investigation, however, shows a definite age-change in Polymorph (Neutrophile), Lymphocyte and Erythroblast Type IV cells and the Leuko-Erythrogenetic ratio shows a tendency to decline with advancing years.

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