Edinburgh M.D. Thesis. April 30. 1902

On the changes in blood in disease

J. Rückhoff M.B. C.M.

CASE.	DISEASE.	DATE.	RED CELLS per c.m.m.	WHITE CELLS per c.m.m.	Neutrophyle Polynuclear per cent	Lymphocytes per cent	Eosinophyle Polynuclear per cent	Myelocytes per cent. Neutrophyle	Myelocytes per cent. Eosinophyle	Nucleated Red. per c.m.m.
NO. 67.	Leucocythaemia. (Myelogenic)	Dec. 9.	2,000,000.	404,000.	40 1/2.	5 3/4.	4 1/4.	48.	1 1/2.	2,525.
		13.		(?) 360,000.	38 3/4.	4 1/2.	3 1/2.	51 3/4	1 1/2	1,406.
		17.	2,400,000.	320,000.	34 1/4.	3 3/4.	3 3/4.	57.	1 1/4	6,757.
		Jan. 2.	2,400,000.	290,000.	—	—	—	—	—	—
		20.		100,000.	62.	2.	3 1/4.	32 3/4.	0.	1307.
		30. (a)	4,000,000.	40,000.	70.	5.	8 1/2.	16 1/2.	0.	1439.
		(b)	4,000,000.	56,000.	54 1/2.	2.	2.	41 1/2.	0.	1037.
		April. 24.	3,900,000.	150,000.	42 1/2.	3 1/2.	3 1/2.	50 1/2.	0.	300.
NO. 68.	Leucocythaemia.		3,200,000,	280,000.						
NO. 69.	Burn.	March. 25.	6,000,000,	24,000.	86 1/2.	13 1/2.				
		March. 26.		22,000.						
NO. 70.	Burn.	April. 5.		19,000.	58.	41.	1.			
		April 14.	4,600,000,	24,000.	65.	35.	0.			
NO. 71.	Burn.			28,000.	80.	20.	0.			
NO. 72	Burn.		6,200,000.	12,400.	90 1/2.	9 1/2.	0.			
NO. 73	Burn.		6,200,000.	23,000.	68.	30.	2.			
NO. 74.	Burn.	March 19.	6,000,000.	30,000.	91.	9.				
		20.	5,600,000.	10,000.	81 1/2.	18 1/2.				
		26.		38,000.	70.	30.				
		April 1.	4,400,000.	32,500.	75.	25.				
NO. 75.	Phenol Poisoning.		5,200,000.	28,000.	89 1/2.	10 1/2.	0.			

Case	Disease	Date	Red Cells. per cubic millimetre	White Cells per c.mm	Neutrophile Polynuclear per cent.	Lymphocytes per cent.	Eosinophile Polynuclear per cent.	Myelocytes per cent.	Nucleated Red per c.mm.
No. 52.	Typhoid.	Feb. 27.	3,500,000.	2,800.	59.	41.	0.		
		March 2.	4,000,000.	10,000.	79.	21.	0.		
		3.	4,000,000.	10,000.	75.	25.	0.		
		4.	5,000,000.	12,000.	77.	23.	0.		
No. 53	Tuberculous Ulceration of Intestine.	Nov 15.	3,600,000.	3,500.					
		19.	2,600,000.	3,000.	71.	29.			
		21.	2,400,000.	2,600					
		27.	2,600,000.	2,600.	72.	28.			
		Dec 2	2,100,000.	2,600.	76.	24.			
		11	2,400,000.	2,600.	80.	20.			
		Jan 10.	2,600,000.	6,000.	68.	32.	1½.		
No. 54.	Hodgkin's Disease.		3,360,000.	6,000.					
No. 55.	Hodgkin's Disease.		4,000,000 75% Haemoglobin	12,000.					
No. 56.	Hodgkin's Disease.		4,000,000.	13,000.					
No. 57.	Purpura. (Boy).		6,000,000.	7,000.	66.	32½.	½.		
No. 58.	Chronic Purpura.		3,040,000.	8,000.					
No. 59.	Pernicious Anaemia		2,800,000.	10,500.					
No. 60	Pernicious Anaemia.	Nov 17.	——	——	40.	59.	1		? 0
		19.	1,300,000.	6,000.	42.	53½.	4½		77.
		21.	1,000,000.	4,500.	57.	45.	3.		? 0
		27.	1,720,000.	3,600.	57.	47½.	1½.		42.
		Dec 11.	2,000,000.	11,200.	87.	13.	0.		
		18.	2,400,000.	5,200.	—	—	—		
		22.	——	——	60.	37.	4.		
		Jan 4.	2,500,000	7,200.	—	—	—		

CASE	DISEASE	DATE	Red cells per Cubic m.m.	White cells per c. m.m.	Neutrophile Polynuclear Leucocytes per cent.	Lymphocytes per cent.	Eosinophile polynuclear Leucocytes per cent.	* Myelocytes	Nucleated Red cells per c. m. m.
NO. 32.	Henoch's Purpura.	March 12.	4,800,000, Haemoglobin 80%	22,500.	81.	15.		2.	248.
		19.	4,000,000.	20,000.	58.	37.	4.	1.	
		April 5.	4,600,000.	8,000.	63.	31.	5½.		
NO. 33.	Chorea.	Nov 19.	4,000,000.	14,000.	71¼.	26½.	2¼.		
NO. 34.	Malignant Ovarian Pregnancy.	Jan 7.	3,600,000.	7,000.	88.	11.	1.		
		16.	3,200,000.	14,000.	87.	12.	1.		
		21.			87.	12.	1.		
NO. 35.	Carcinoma Ventriculi.		4,400,000.	15,000.	72.	28.	0.		
NO. 36.	Chronic Gastric Catarrh.		4,400,000.	9,400.					
NO 37	Sarcoma of Lung.			9,500.	84.	11 Small, 4½ mono-nucl.	½.		
NO. 38.	Sarcoma of Temporal Bone.		4,400,000.	12,000.	70½	22.	7½.		
NO. 39.	Cerebellar Tumour.		4,800,000.	4,800.					
NO. 40.	Sarcoma of Orbit.		5,000,000.	6,000.	57.	42.	1.		
		Feb 10.		9,000.	56½.	42.	1½.		
		11.		4,500.					
		12.		4,800.					
		14.	5,500,000.	5,500.	76.	23.	1.		
		18.		6,600.					
		26.		5,000.	69.	29.	2.		
		M[illegible]							

Case	Disease.	Date.	Red Cells per c.m.m.	White cells per c.m.m.	Neutrophyle Polymuclear per cent	Lymphocytes per cent	Eosinophyle Polymuclear per cent	Myelocytes per cent.	Nucleated Reds per c.mm.
No. 19.	Acute Rheumatism (Late stage)		Haemoglobin 63%	13,000.					
No. 20.	Tuberculous Peritonitis	March 17.	4,400,000.	9,000.	80.	20.	0.		
		20.	4,200,000.	13,000.	78.	22.	1.		
No. 21.	Tuberculous Kidney	March 17.	4,700,000.	22,000.	68½.	29½.	2.		
		27.	4,400,000.	9000.	81.	14.	0.		
No. 22.	Basal Meningitis	Jan 31.		8,000.	40.	58.	2.		
		March 4.	5,200,000.	15,000.	30.	67½	2½.		
No. 23.				25,000.	90½.	8.	1½.		
No. 24.	Ruptured Ovarian Gestation.		2,600,000.	28,000.	98.	2.	0.		
No. 25.	Gall stone in Common Duct.	Feb 20	4,800,000.	10,000.	89.	11,	0.		
		22.	4,800,000.	13,000.	83	17.	0.		
		25.		10,000.	78	18.	4.		
No. 26.	Biliary Lithiasis.	Jan 28.	4,800,000.	8,000.	72.	26½.	1½.		
		31.		8,200.	78.	21.	1.		
		Feb. 7. 4.15 Pm.		11,000.	62.	38.	0.		
		9.30 Pm.		6,000.					
		Feb. 11.	3,600,000.	8,000.	67.	31½.	1½.		
		14.		7,000.	60½.	40.	0.		
		18.		7,000.					
		22.	4,800,000						

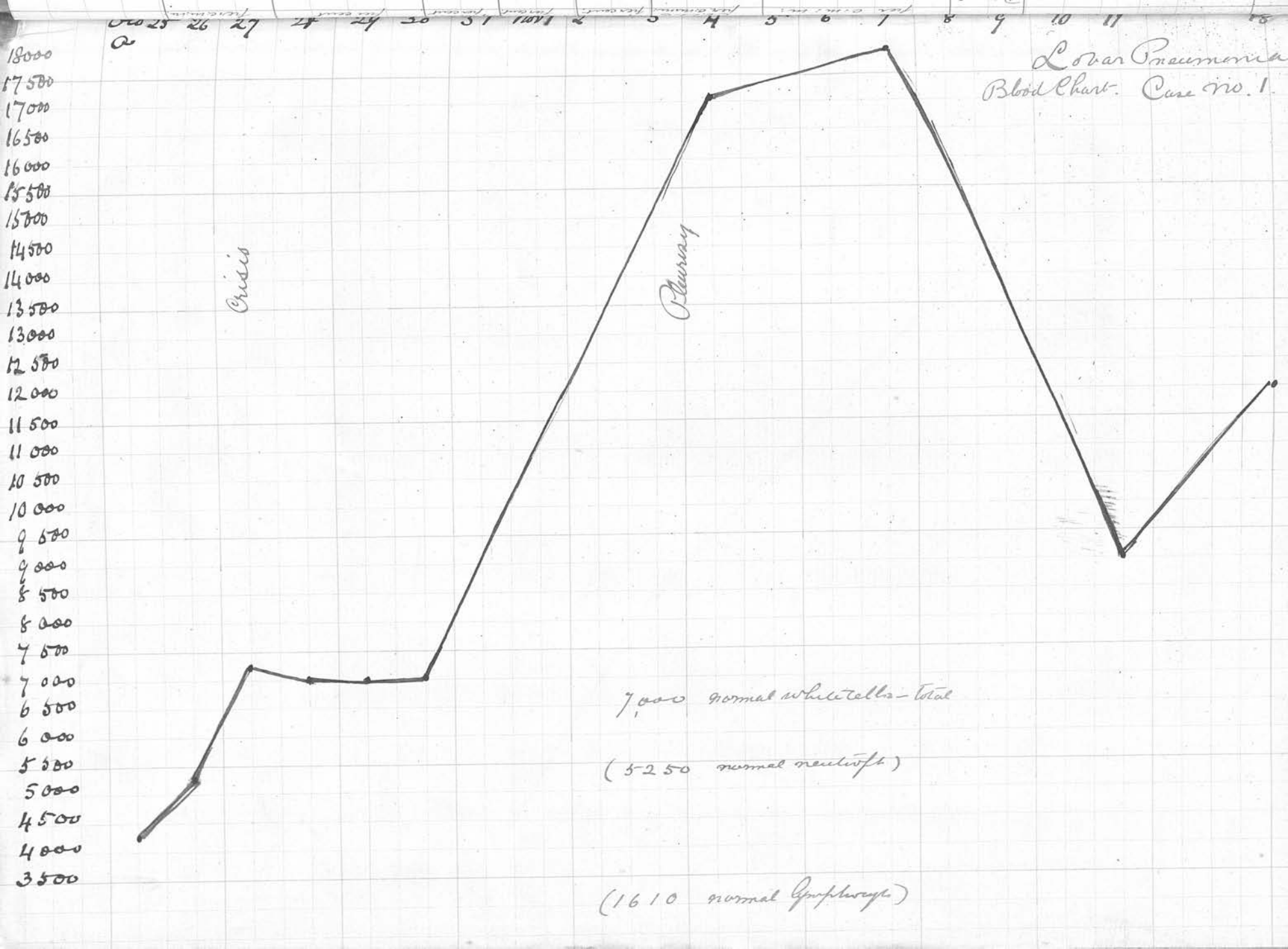
CASE	DISEASE	DATE	RED CELLS per cubic millimetre	WHITE CELLS per c.m.m.	Neutrophile Polynuclear per cent.	Lymphocytes per cent.	Eosinophile Polynuclear per cent	Myelocytes per cent	Nucleated Reds per c.m.m.
NO. 1.	Lobar Pneumonia	Oct. 25	4,000,000.	4,200.					
		26	4,000,000.	5,200.					
		27		7,200					
		28		7,000					
		29		7,000					
		30		7,000					
		Nov 4		17,400					
		7		16,000					
		11		9,000					
		18		12,000					
NO. 2.	Lobar. Pneumonia	Nov 13	4,500,000.	35,000	97.	3.	0.		
		16	3,600,000.	24,000					
		17	4,500,000.	20,000	89.	10.	½ about		
		19		15,000.	77.	22½.	½.		
NO. 3.	Tubercular Broncho-Pneumonia	March 17	2,800,000. Haemoglobin 30%	21,600.	61.	39.	⅓ about		67.
		20	2,200,000.	26,000.	80.	20.	⅓ about		135.
NO. 4.	Appendicitis (Catarrhal)		3,000,000.	7,500.					
NO. 5.	Appendicitis (Catarrhal)		3,400,000.	11,000.	72½	27	½.		
NO. 6.	Appendicitis. & Small Abscess.			15,000.					
NO. 7.	Lateral Sinus Disease & Pyaemia.		3,000,000.	16,000.	96½	3½	0		
NO. 8.	Thrombosis of Lateral Sinus.		4,400,000.	14,000.	82	18	¼ about.		

.9.	Thrombosis of Lateral Sinus, c̄ Pyaemia.	Jan: 2.	4,400,000,	20,000.						
		5. morning		11,000.	91.	9.	0.			
		5. afternoon		15,000.	87½.	12½.	0.			
10.	Lateral Sinus Disease, c̄ Meningitis.	Jan 7.	4,200,000,	6,000,	79.	21.	0.			
		8.	3,000,000,	11,000,	96.	4.	0.			
		9.	2,800,000,	18,000,						
11.	Lateral Sinus Disease		4,000,000,	4,000,	95.	4.	1.			
12.	Empyema.		4,100,000,	24,000.	94½.	5½.	0.			
13.	Perforating Gastric Ulcer. (Pus in Lesser Sac).		5,000,000,	40,000.	98	2.	0.			
.14.	Perinephritic Abscess c̄ Uraemia.		4,000,000,	24,000.	92½	7½	0			
0.15.	Pyelo-Nephritis.		3,000,000.	11,000.	79	21	0			
			3,600,000.	10,000.	78	22	0			
0.16.	Gonorrhoeal Rheumatism	Nov: 5.	5,000,000.	3,600.	68½.	28	3½			
		8.	5,200,000.	4,000.	60.	38½	1½			
0.17.	Ulcerative Endocarditis.		2,700,000.	7,500.	76.	22.	0	2.		150.
0.18.	Acute Bronchitis		5,000,000.	12,000.						

27.	Biliary Obstruction. ? Pancreatitis.	Jan 25.	4,600,000.	9,000.	61½.	36½.	2.	
		Feb. 1	4,000,000.	17,000.				
		Feb 2.		16,000.				
		4.		18,000.	95.	5.	0.	
		7.		20,000,	91.	8½	0.	
		8.	4,000,000.	18,000.	92.	7.	1.	
		22.		6,500.	94.	6.	0.	
28.	Malignant Peritonitis.	March 1.	4,800,000.	11,000.	89.	10½.	0.	
		11.	3,000,000.	19,000.	92½.	7½.	0.	
29.	Cystic Ovarian Tumour.	Feb 27.	4,800,000.	6,000.				
		March 1		8,800.	88.	12.	0	
		10	4,500,000.	7,000.	71½.	26.	2½.	
30.	Dilated Stomach.	Jan 23.						
		7. AM.	5,200,000.	5,300,	95.	5.	0.	
		9. A.M.		6,000.	78.	18½.	3½.	
		24.	4,600,000.	18,000.	67½.	29½.	3.	
		9 A.M. 7.30 P.M		19,000.	93.	7.	0.	
		25.	4,500,000.	15,000.	80.	18.	2.	
		27.	5,000,000.	8,000.	79.	17.	4.	
31.	Simple Pyloric Stenosis.	March 6	4,400,000.	8,400.	79.	20½.	½.	
		11.	5,000,000,	7,500.	87.	12½.	½.	
		26.	4,000,000.	11,000.	74.	24½.	1½.	

Case	Disease	Date	Red Cells. Per c.mm	White Cells. Per c.mm	Polymorphonuclears per cent	Lymphocytes per cent	Eosinophiles per cent	Red cells.
No. 41.	Rodent Ulcer.		5,200,000.	6,000.	69½	30½	about 1/3.	
No. 42.	Intra-Cranial Tumour.		4,400,000.	14,000.				
No. 43.	Round worm in Small Intestine.	Nov. 9.			61¾.	30¾.	7½.	
		16	5,200,000.	12,000.	52½.	32½.	13.	
		Dec. 11.	5,000,000.	10,000.	63½.	30½.	6.	
No. 44.	Actinomycosis.	Oct. 7.	5,290,000.					
		8.	4,960,000.	4,600.	83.	17.		
		9.	5,140,000.	5,000.				
		15.	3,800,000.	4,000.	71½.	27½.	1.	
No. 45.	Pemphigus.		4,600,000.	18,000.	88½.	5½.	6.	
No 46.	Bilharzia Haematobia.	Apr. 14.	5,600,000.	8,000.	59.	37.	2½.	
		24.			66.	31.	2.	
No. 47.	Malnutrition (Baby).		4,000,000.	15,000.	27.	70.	3.	
No. 48	Rectal Feeding.		4,000,000.	5,000.	51½.	44.	4½.	
No. 49.	Typhoid.		4,500,000.	7,000.	66.	34.	0.	
No. 50.	Typhoid. Child.		5,400,000.	7,000.				
No. 51.	Typhoid. (1 week)	Oct. 6.	5,007,000.	4,000.				
		11.	4,500,000.	1,600.				

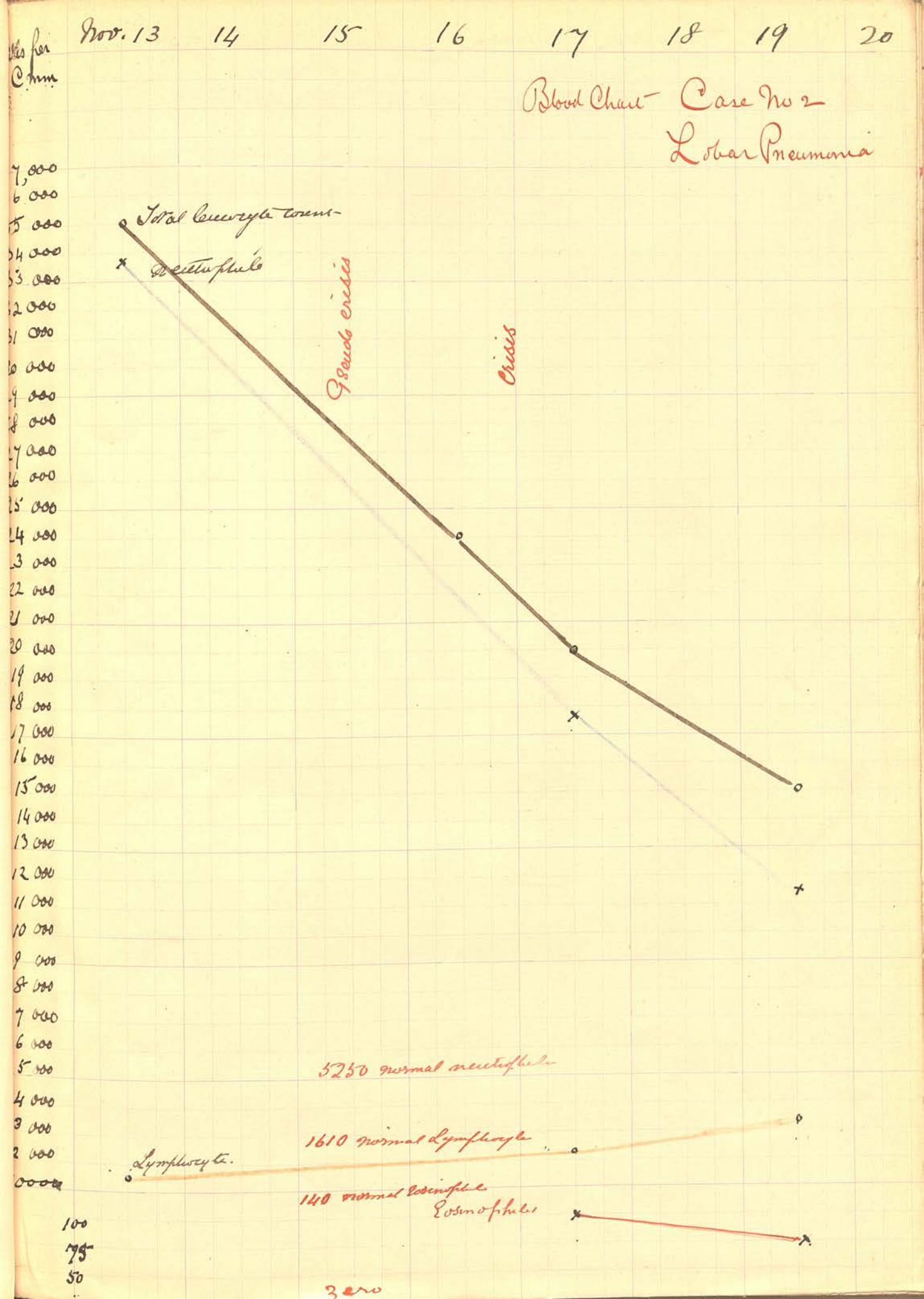
			per c.m.m.	per c.mm.	per cent.	per cent.	per cent.	per cent.	per c.m.m.
No 76.	Belladonna Poisoning.	Dec 3. 8 P.M. 11.45	5,000,000. 6,000,000.	24,000. 18,000.					
No.77.	Superficial Keratitis.		4,900,000. Haemoglobin 53%	4,800.	80.	19½.	½.		
No.78.	Superficial Keratitis.		5,000,000. Haemoglobin 72%	6,600.	63½.	33½.	3.		
No.79.	Superficial Keratitis.		4,600.000. Haemoglobin 63%	9,000.	47½.	47½.	5.		
No.80.	Superficial Keratitis.		4,600,000. Haemoglobin 68%	13,500.	80.	20.	0.		
No.81.	Cretin.		4,800,000.	14,000.	79.	20.	1.		
No.82.	Enlarged Spleen.		4,800,000.	7,000.	55.	33.	12.		
No.83.	Subacute Rheumatism		4,000.000. Haemoglobin 55%	17,000.					


Lobar Pneumonia
Blood Chart. Case No. 1.
Crisis
Pleurisy
7,000 normal white cells - total
(5250 normal neutrophyls)
(1610 normal lymphocytes)
18000
17500
17000
16500
16000
15500
15000
14500
14000
13500
13000
12500
12000
11500
11000
10500
10000
9500
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500

Nov. 13 14 15 16 17 18 19 20

Blood Chart Case No 2

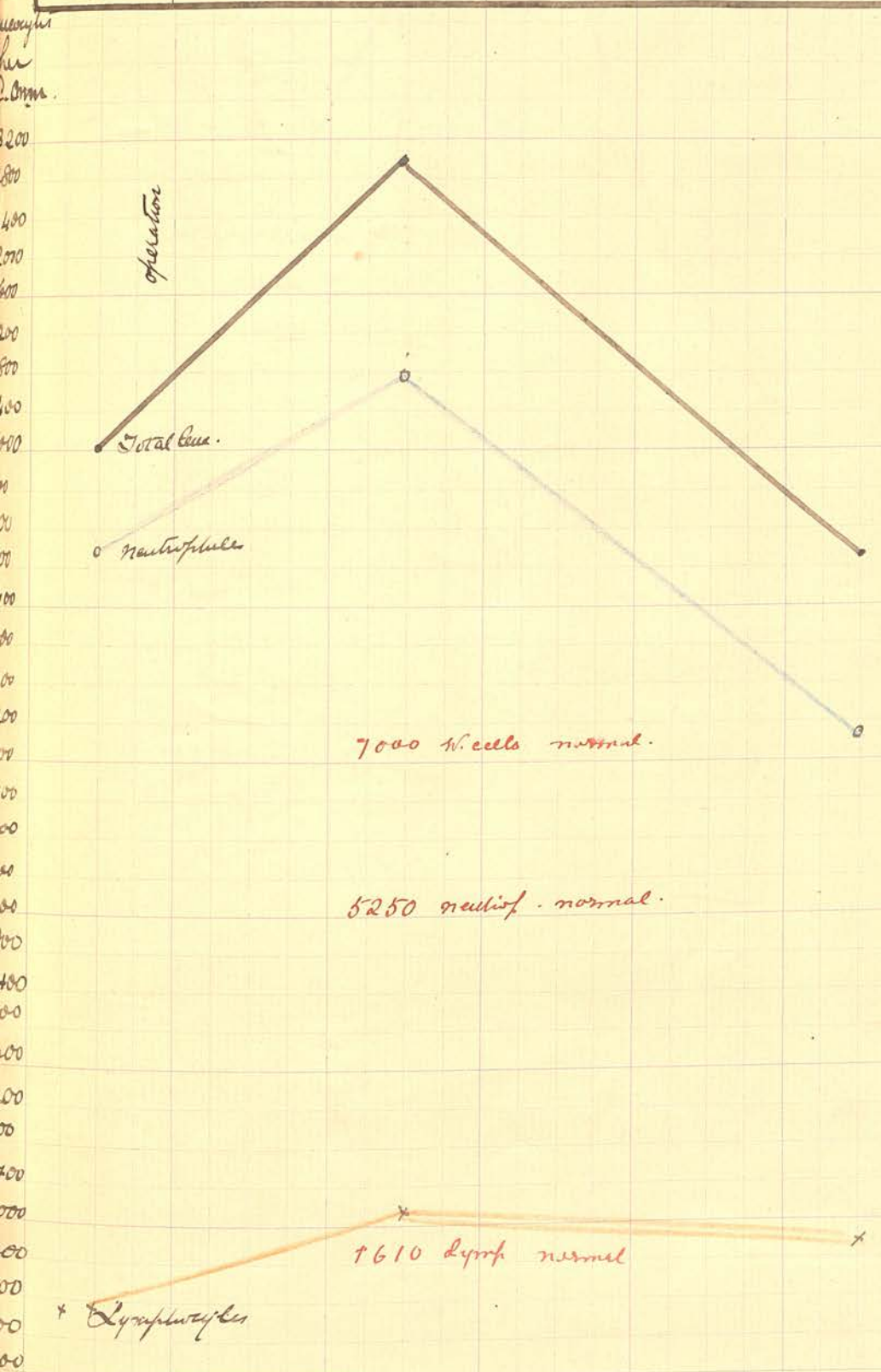
Lobar Pneumonia



Blood Chart Case No 25- Gall Stone in Common Duct

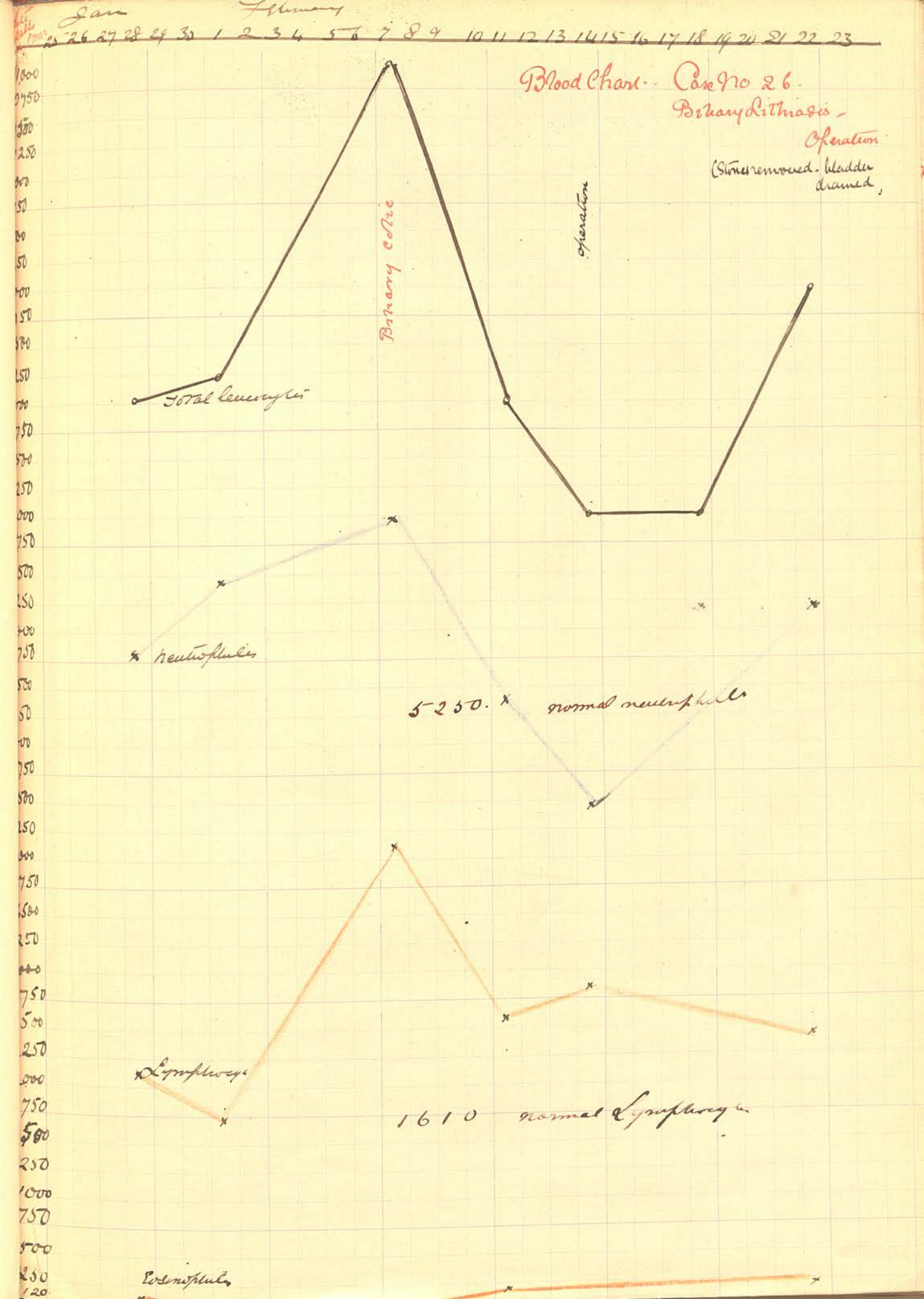
Stone removed - bladder drained Operation

Feb 20	21	22	23	24	25-	26



Lovelace Gall Stone in Common Duct

Case 25


Jan
February
26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Blood Chart. Case No 26.
Biliary Lithiasis -
Operation
(Stones removed. bladder drained,
Biliary colic
Operation
Total leucocytes
neutrophiles
5-250. normal neutrophiles
Lymphocytes
1610 normal Lymphocytes
Eosinophiles

Hanson Bakery Letters

Case 26

January February

25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Blood Chart

Case No 27. Biliary Obstruction

Operation (Cholecystectomy

Operation Jan 31.

Total white cells

7000 White cells normal

Neutrophiles

5-250 Neutrophiles normal

Lymphocytes

1610 Lymphocyte normal

Pancreatitis - Biliary obstruction.

Case 27 Kendall

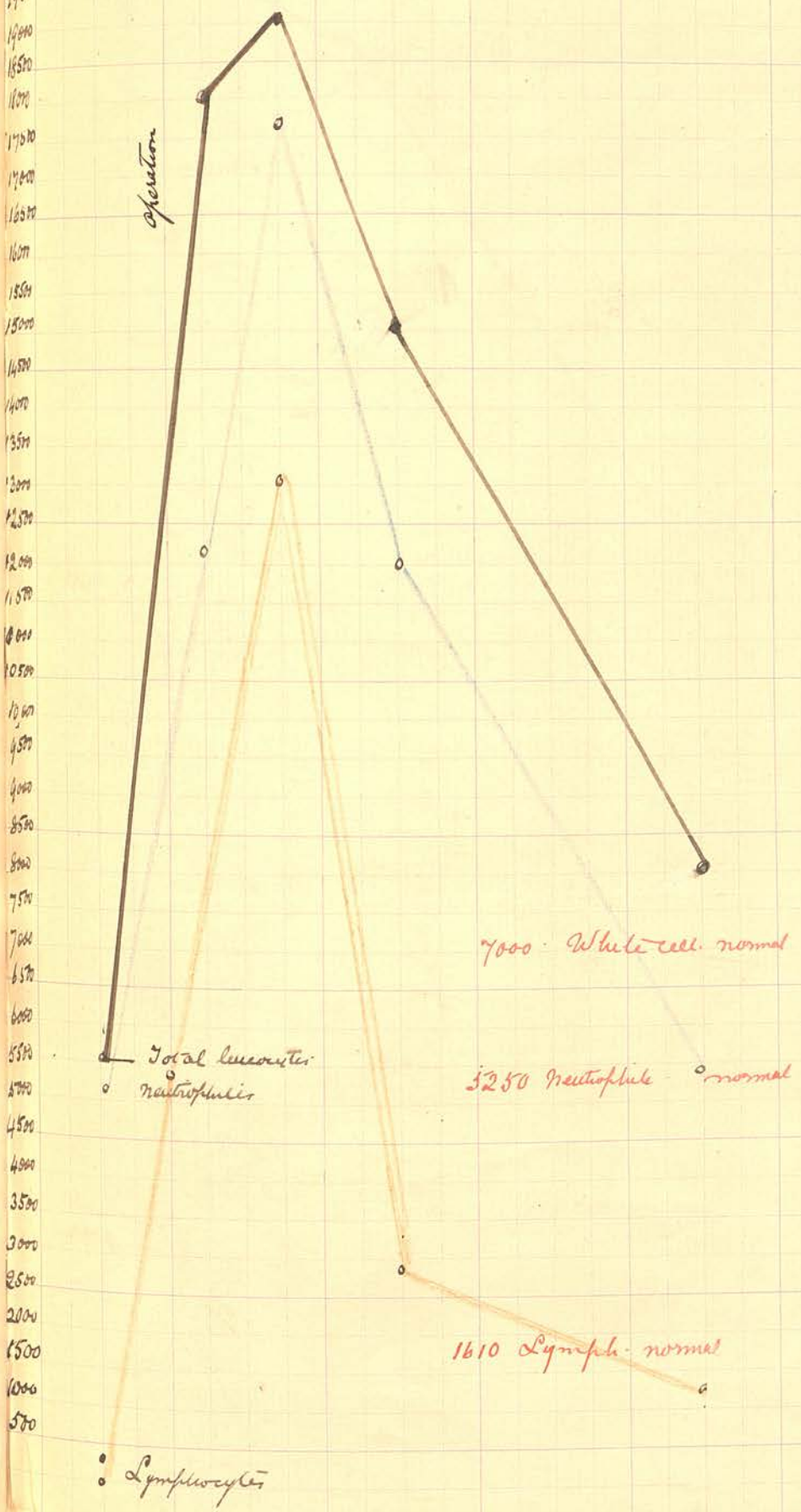
Jan 23 24 25 26 27 28

morning evening

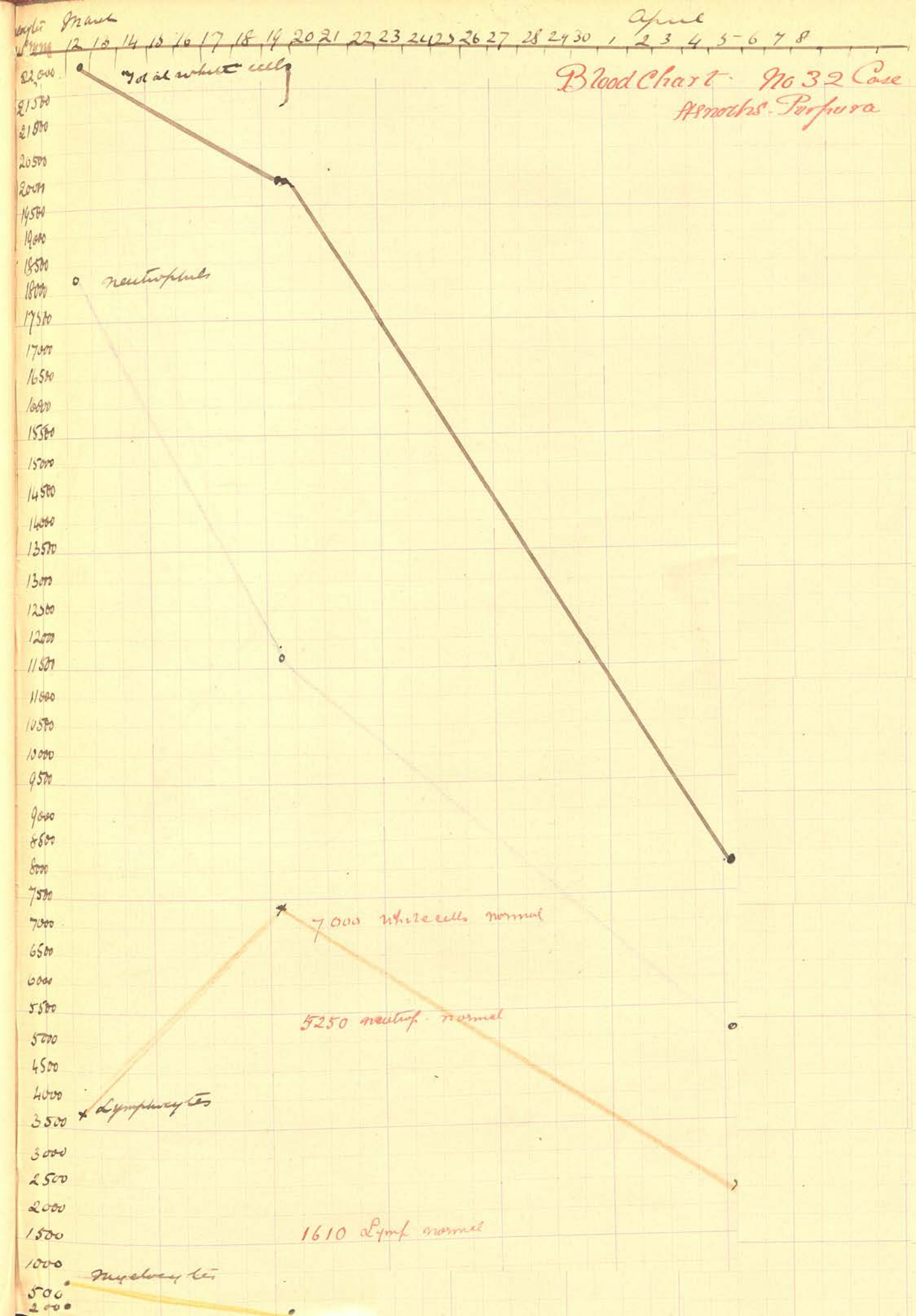
Blood Chart – Case No 30

Dilated Stomach

(Gastro-Enterostomy)



Beale Dillard Stroud
Jan 30


March
April
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8
Blood Chart No 32 Case
4 months Purpura
Total white cells
neutrophiles
7000 White cells normal
5250 neutrop. normal
Lymphocytes
1610 Lymp normal
Myelocytes
22,000
21500
21000
20500
20000
19500
19000
18500
18000
17500
17000
16500
16000
15500
15000
14500
14000
13500
13000
12500
12000
11500
11000
10500
10000
9500
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
200

Chas Prince.
Cas 32.

Stewarts Purpura

February

7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 March 2 3 4 5 6

Blood Chart — Case No 40. Sarcoma of Orbit

Coleys fluid every 3rd Day

Coleys fluid Rigor

7000 White cells normal

Total leucocytes to cmm

5250 · Neutrophil normal

Neutrophiles

Lymphocytes

1610 Lymphocyte normal

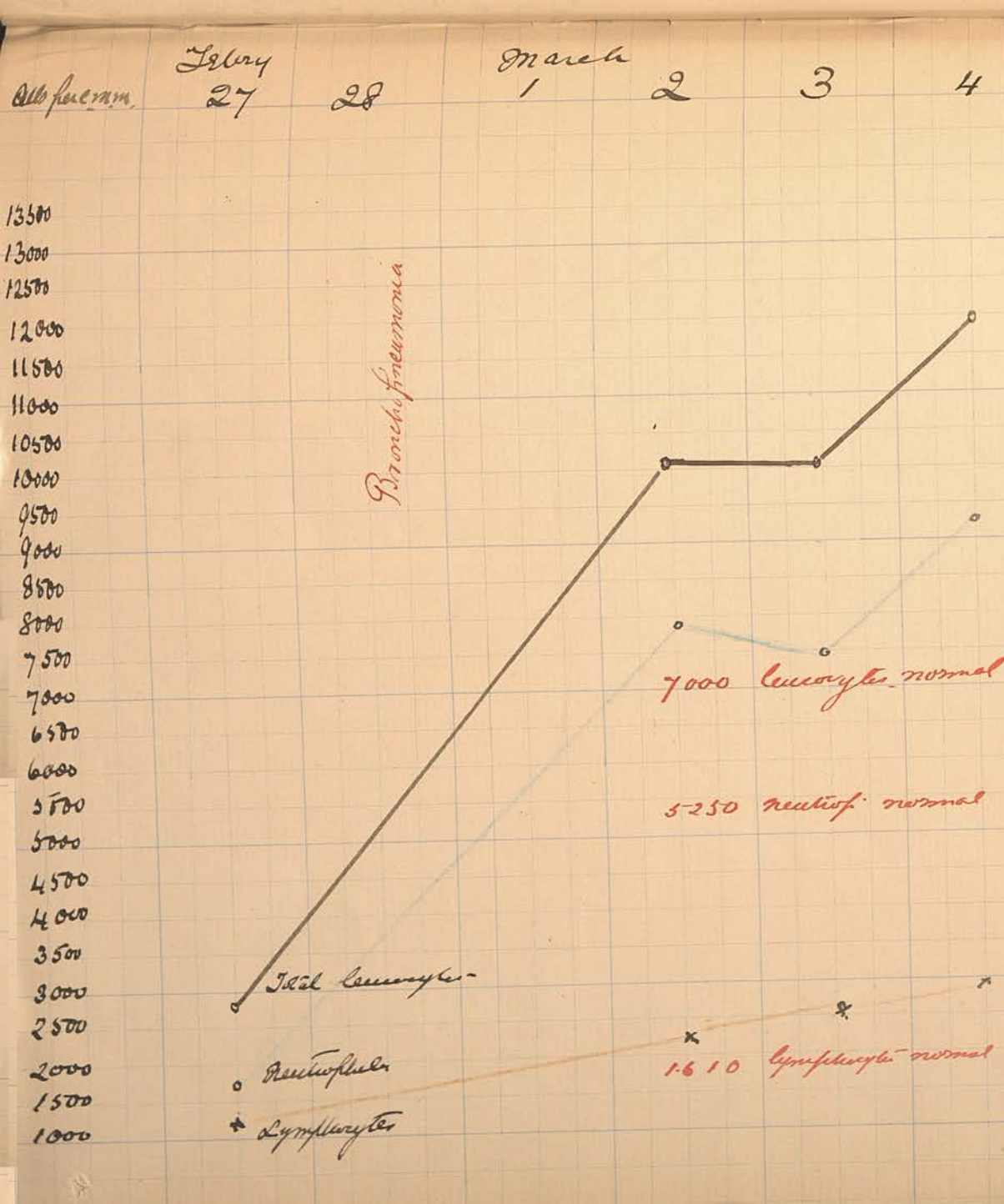
140 Eosinophile normal

Eosinophiles

Oldfield - Salem

Blood Chart – Case No 52

Typhoid & Complication.



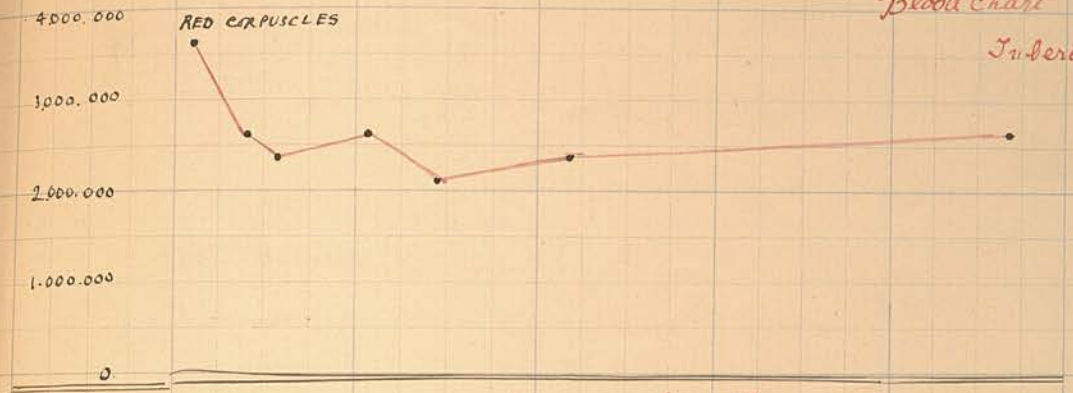
DATE

November 15 18 21 24 27 30 December 3 6 9 12 15 18 21 24 27 30 January 2 5 8 11

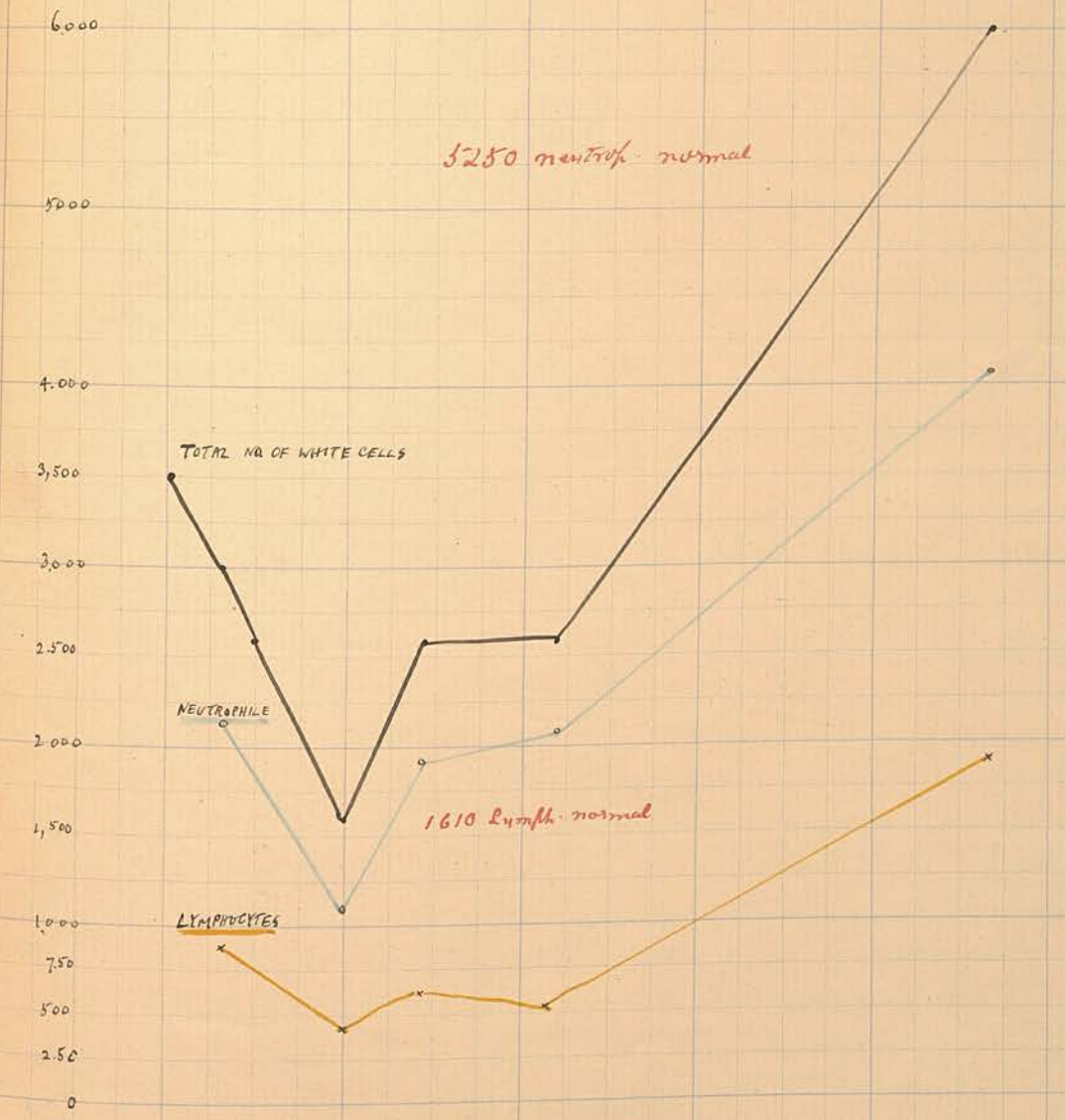
Cells per cubic millimetre

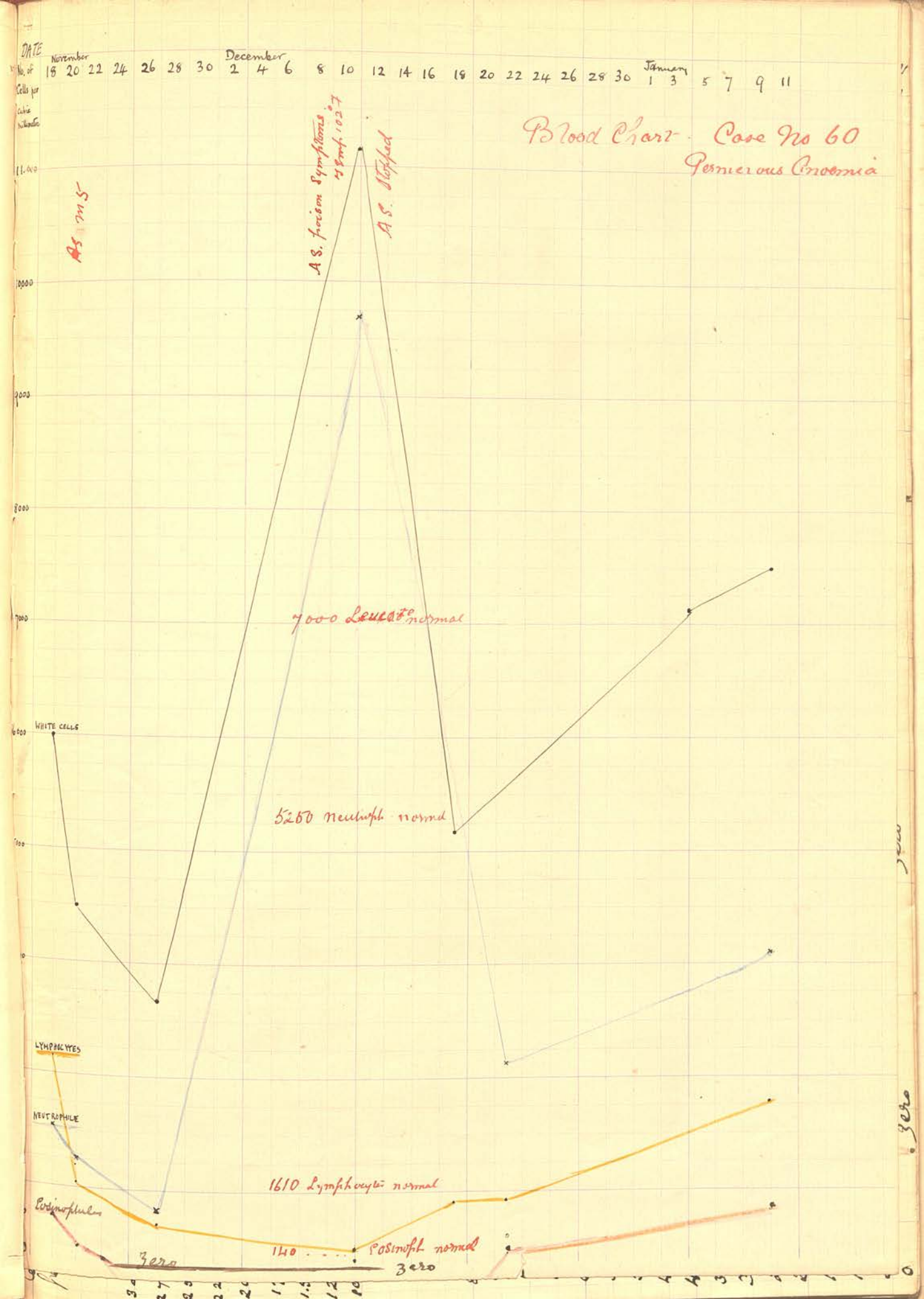
Blood Chart Case No 53.

Tuberculous ulcer of Intestine



7000 white cells normal




DATE
November
December
January
18 20 22 24 26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 1 3 5 7 9 11
No. of Cells per Cubic Millimeter
11,000
10000
9000
8000
7000
6000
WHITE CELLS
LYMPHOCYTES
NEUTROPHILE
Eosinophiles
Zero
Blood Chart. Case No 60
Pernicious Anemia
A.S. Jan 5
A.S. Jan 5 Symptoms Temp. 102°F
A.S. Satisfied
7000 Leucocytes normal
5260 Neutrophil normal
1610 Lymphocytes normal
140 Eosinophil normal
Zero
Zero

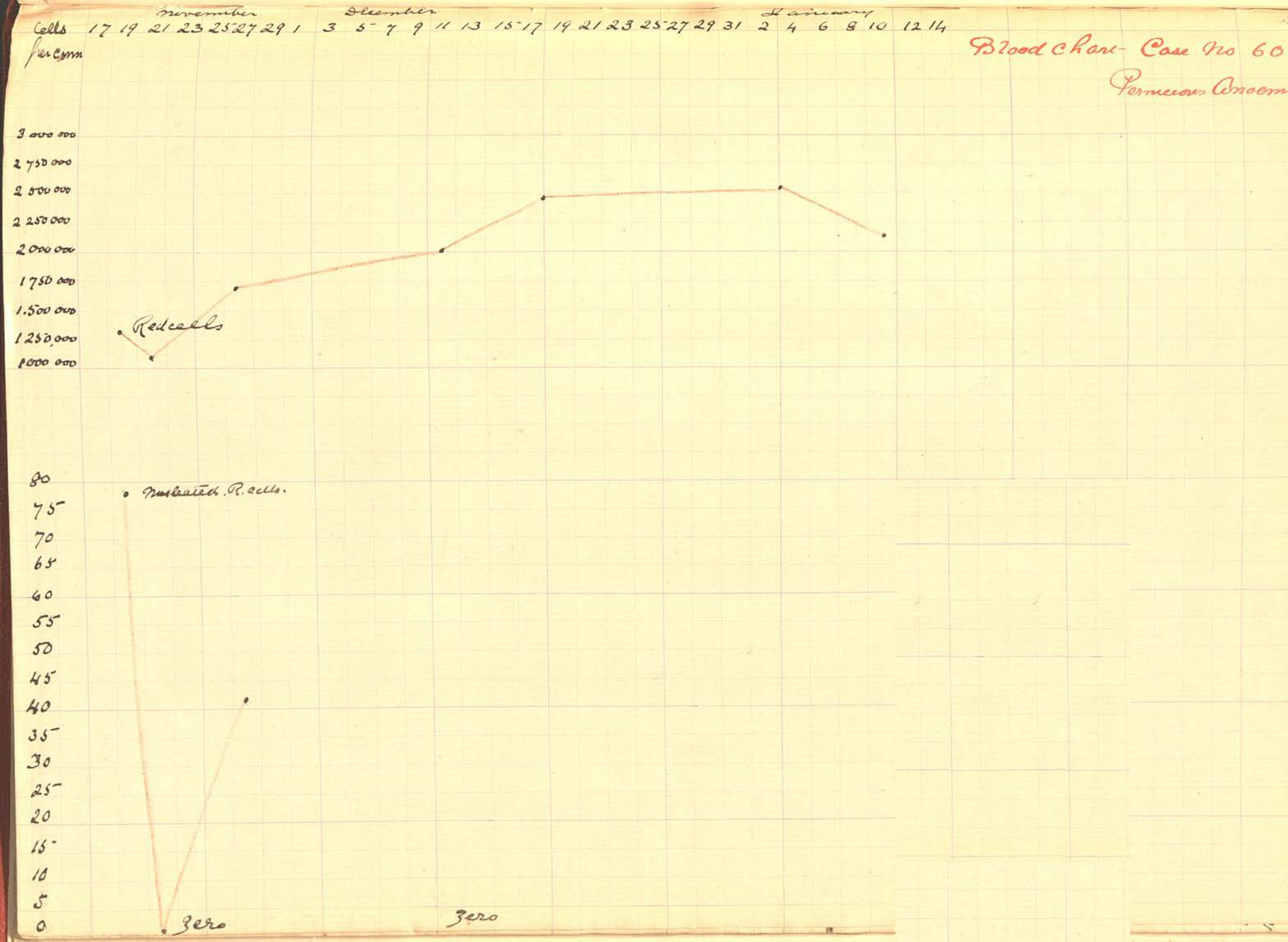
Pers 60

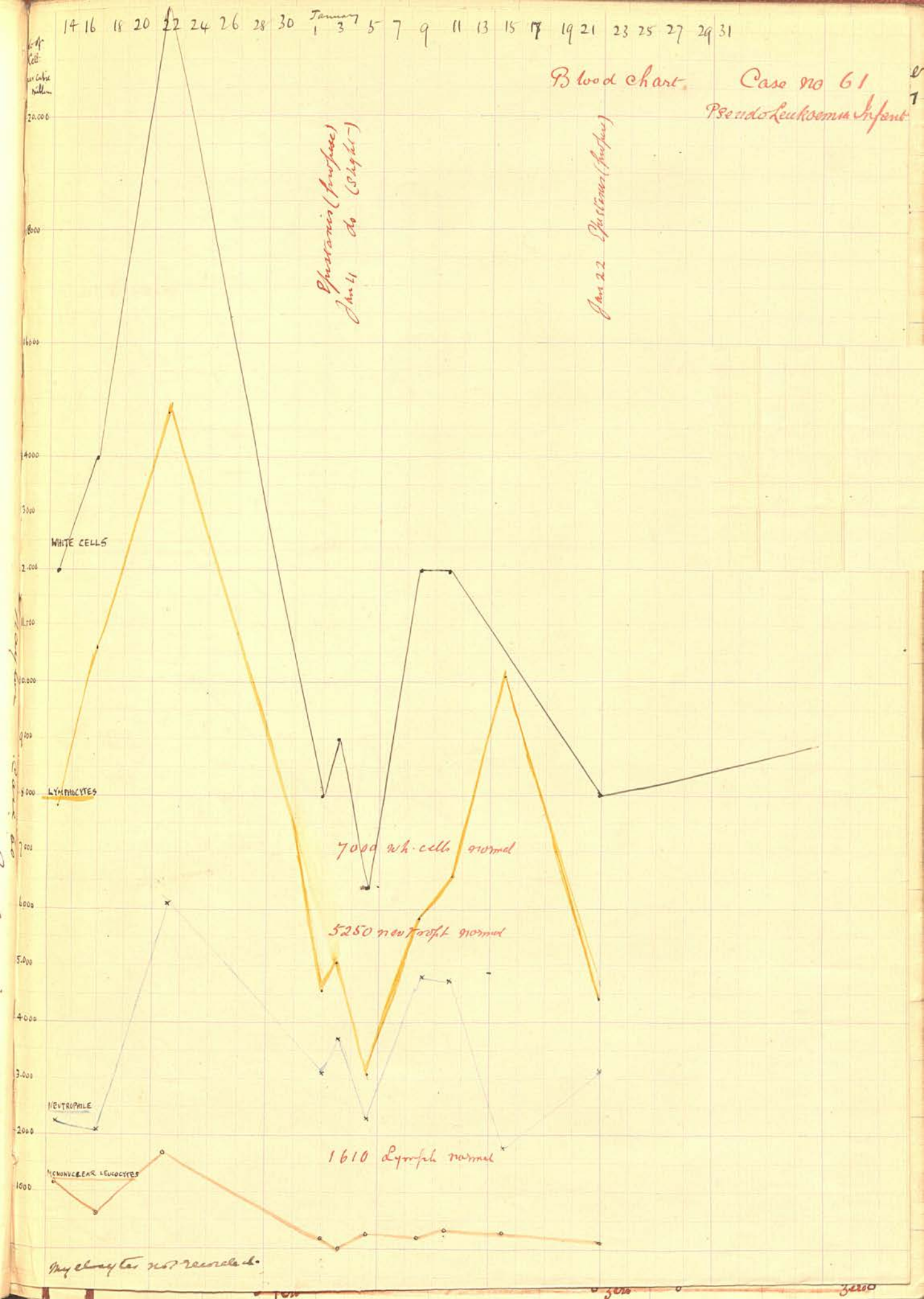
Pers. Amoenus

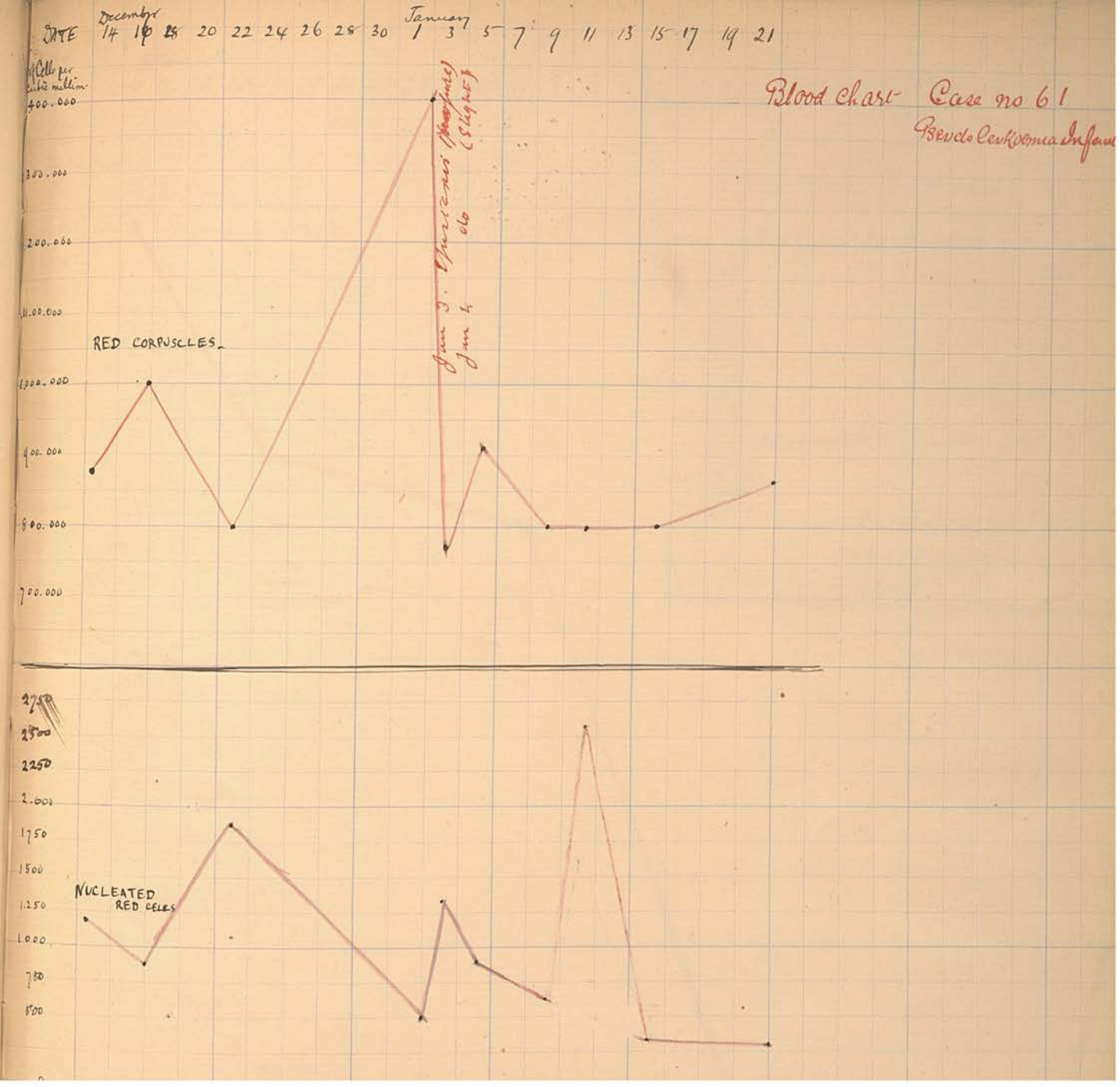
Naylor.

Blood chart - Case No 60

Pernicious Anaemia




14 16 18 20 22 24 26 28 30 January 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Blood chart Case no 61
Pseudo Leukaemia Infantum
Jan 21 Pharyngitis (Streptococ)
Jan 22 Splenomegaly (Streptococ)
WHITE CELLS
LYMPHOCYTES
NEUTROPHILE
MONONUCLEAR LEUCOCYTES
7000 wh. cells normal
5250 neutrophil normal
1610 Lymph normal
20.000
18000
16000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000


DATE
December
14 16 18 20 22 24 26 28 30
January
1 3 5 7 9 11 13 15 17 19 21
Cells per cubic millim.
400.000
300.000
200.000
100.000
RED CORPUSCLES
Jan 3. Hemorrhage (Metrorrhagia)
Jan 4 do (Slight)
Blood Chart Case no 61
Bendo Leukaemia Infantum

2750
2500
2250
2000
1750
1500
1250
1000
750
500
NUCLEATED RED CELLS

Blood Chart. Leucocythaemia Case no 67

DATE: November 9 11 13 15 17 19 21 23 25 27 29 31 — January 3 6 9 12 15 18 21 24 27 30 — Febry 2 6 20 — March 14 — April 24

No. of cells per cub. mm.

Total number of white cells

400 000
87 500
75 000
62 500
350 000
37 000
25 000
12 500
300 000
250 000
200 000
150 000
100 000
50 000
37 500
25 000
12 500
0

AS. m3 r.a. — AS m6 r.a. — AP m8 r.a. — AS m12 — AS m15 — AS m20

myelocytes

Neutrophile polymuclears

Lymphocytes

Eosinophile polymuclears

Eosinophile myelocytes

2300
2000
17 000
14 000
11 000
8000
5000
2 000
1000
0

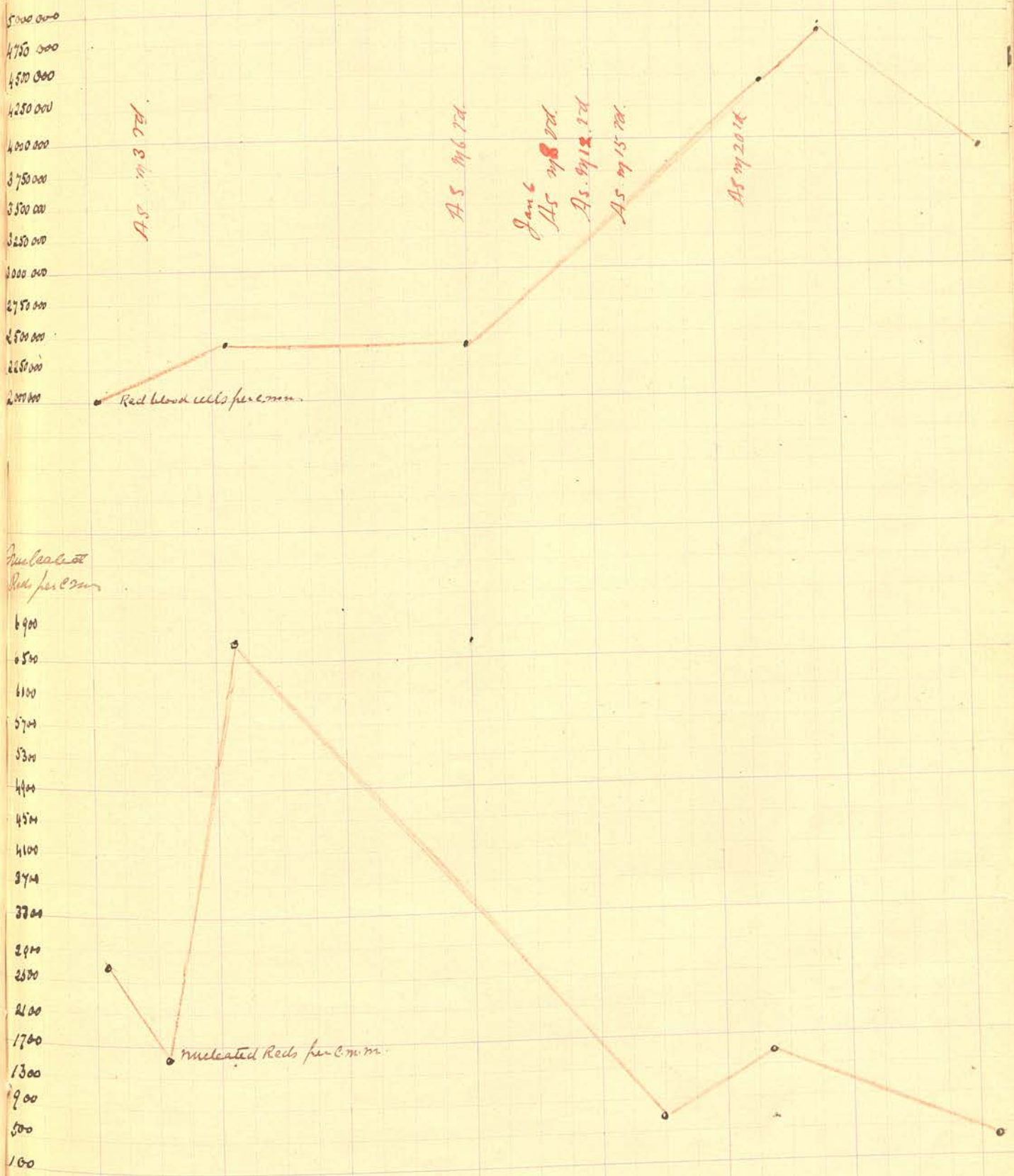
Zero — Zero — Zero

Normal Ratio of White cells per cubic millimetre

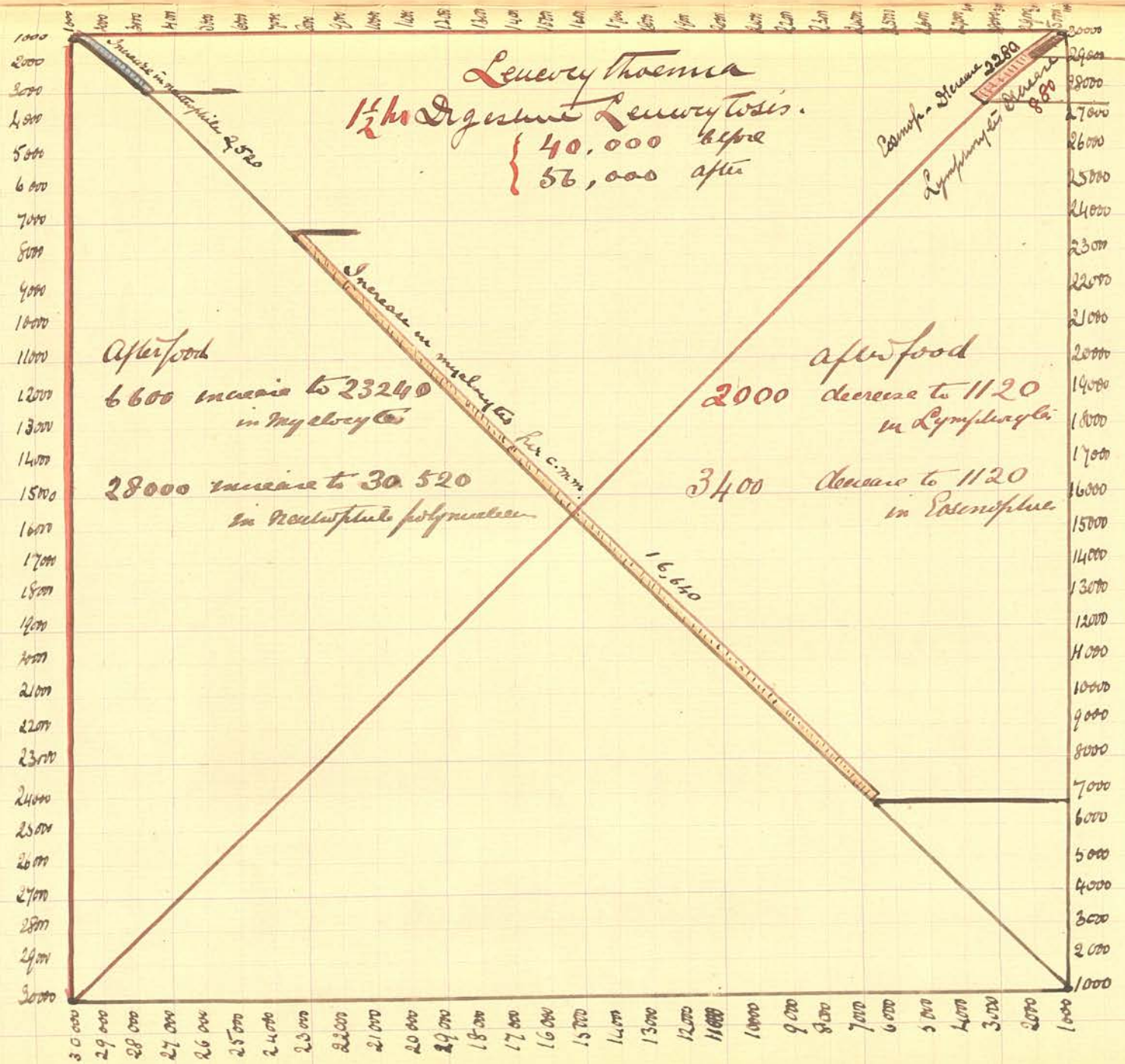
5110	Neutrophiles	73 %
1575	Lymphocytes	22.5 %
210	eosinophiles	3 %
105	Monomuclears	1.5 %
Total per cmm.	7000	

Leucocythaemia

Blood Chart — Case No 67



Case No 67

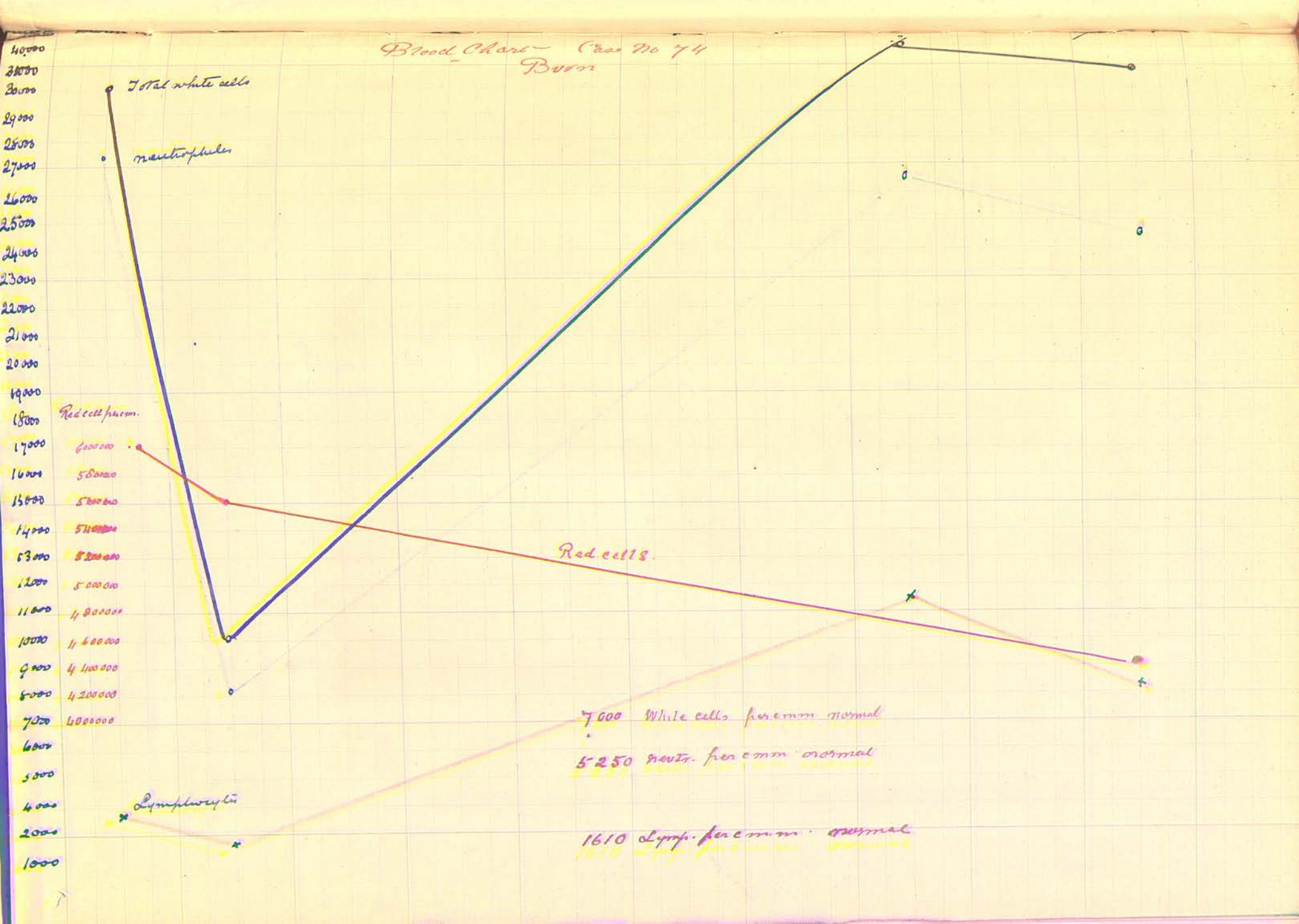


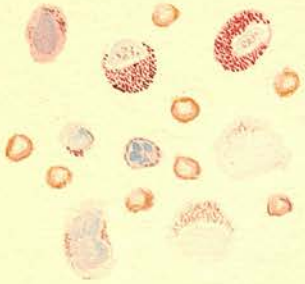
Leucocythaemia

Jan 30 RBC 4 000 000

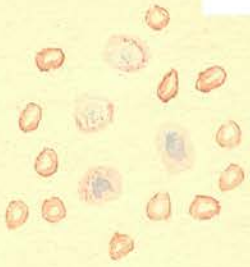
Infusion Bloodclot

Before tea	1½ hr. after tea
40 000	56 000
6 600 Myelocyte	23 240
28 000 Neutrophile	30 520
2 000 Lymphocyte	1120
3 400 Eosinophile	1120

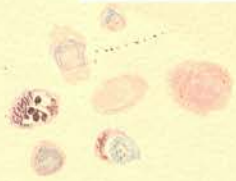

Blood Chart — Case No 74
Burn
Total white cells
neutrophiles
Red cell per cm.
6000000
5800000
5600000
5400000
5200000
5000000
4800000
4600000
4400000
4200000
4000000
Red cells.
Lymphocytes
7000 White cells per cmm normal
5250 neutr. per cmm normal
1610 Lymp. per cmm normal



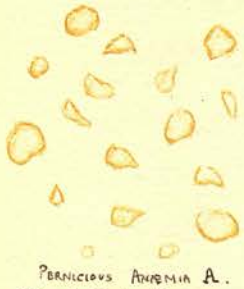
Leucocythæmia A
Before treatment with Arsenic



Leucocythæmia B.
After treatment with Arsenic

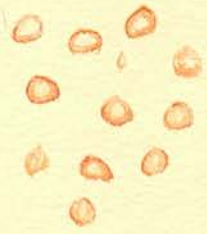


Pseudo-Leukæmia



Pernicious Anæmia A.
Before treatment with arsenic

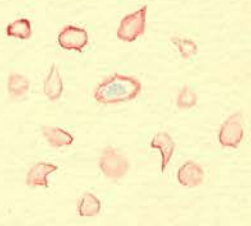
Pernicious Anæmia B.
After treatment with Arsenic



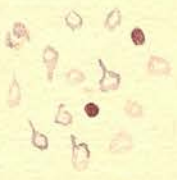
Pseudo-Leukæmia

Red cells in a Burn

In Another Burn



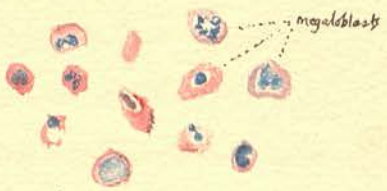
Red Cells in Secondary Anæmia (& post-partum)



Red cells in Ulcerative Endocarditis

A. Leucocythæmia

B. Pseudo-Leukæmia



C. Ulcerative Endocarditis

G.C. GRUNER

Nucleated Red Cells.

The changes in the blood in disease have of late received much attention. The changed condition of the blood in Leukaemia was discovered by Virchow and Bennet That there are changes in the blood in most diseases has only of late become clearly known Ehrlich in introducing differential staining to demonstrate the varieties of leucocytes put the study of blood diseases on a new basis. Though important variations in the number of white & red cells were found their true significance was not rightly interpreted A high leucocyte count might indicate two very different conditions only to be distinguished by differential staining In Leukaemia a count of 40.000 might be found, and on the other hand an Empyema or Suppurative peritonitis might produce a leucocytosis as high as 40,000. The differential staining at once establishes the true distinctions. A true Leukaemia (myelogenic) might in a similar way be confounded with a Pseudo leukaemia.

The ordinary term of leucocytosis even becomes modified by the facts brought to light in differential counting. A count of 12.000 leucocytes does not necessarily indicate the increase of the active amoeboid white cells which so frequently occurs in infective ~~fevers~~ diseases. It may mean an increase of lymphocytes, a lymphocytosis, and no change in the number of the neutrophile white cells.

This distinction is moreover not an unimportant one owing to the uniformity of the increase of the one or the other variety in certain diseases. The significance of the variations in number of the neutrophils as better known than those in the number of the lymphocytes. The consistent relationships of the varieties of cells in the blood during the progress of the one disease and their

constant ratio in the same class of cases become the more remarkable when we recollect the large number of kinds of cells in the blood. Side by side in one fluid medium are cells which react differently to the same disease. Even a casual observer must notice how very separate the red cells are from the white cells in their reaction to disease. Like the sensitive balancings of the mercury in the thermometer are the white cells in their reaction to disease or physiological influences. The steady progress of the disease on the other hand is firmly established by the rate of progress in the number & quality of the red cells. It is the "weight chart" in blood records. This I will show afterwards in several cases.

The methods I have employed in the study of the 83 cases tabulated are to count the red & white cells in their number per c.m.m., and if necessary also to make a Haemoglobin estimate. For the former a Thoma-Zeiss instrument was used & for the latter Fleischl's Haemoglobinometer. For the purpose of differential counting I made cover-slip preparations and for the convenience of it as well as for the good results obtained fixed them at 120°C for a few hours and stained with Ehrlich's triple stain.

Considered as Normal

RBC: 5,000,000
WBC 7,000

Neutrophiles	5250	75%
Lymphocytes	1610	23%
Eosinophiles	140	2%
	7000	

Large mono nuclears were counted under Lymphocytes

Even to the busy general practitioner the clinical value of blood examination is so great that it should not be omitted even in diseases outside those termed "blood diseases". So much value is paid to the temperature chart and the pulse & respiration rates that it would appear strange to pay less attention to the subtle delicate changes in the blood - changes often more reliable than the temperature chart. In a few hours

the white cells may rise from 7000 to 30,000.
A fall in temperature may be fallacious as a sign of progress when the Leucocyte Count would still be a true indication. As an example, note the Pseudocrisis of a Pneumonic – Case No 2. The Changes in the blood however must only be accessory aids to the Clinical data. As such accessory aids, no one will fail to recognise their clinical value and indeed as such they will become indispensible. The Specialist has the privilege of studying closely and consistently certain phenomena in blood changes but no less valuable work can be done by the Clinician for he has a fuller view of the case, and often the clinical features of a case are supplementary not only to but also explanatory of the change in the blood. If only to correct the general opinion of "Anaemia" how valuable this result would be! The apparently anaemic may be found to have a full number of red cells – the rosy flushed patient to be profoundly anaemic. Case No 2

I intend in the following pages to indicate the Chief changes in the White & red cells in disease, with fuller references, and some inferences from more detailed cases. And of all the changes indicated I hope to find illustrations out of the number I have studied during the last 6 months in the Leeds General Infirmary. As only the broad outlines of this extensive and intricate Subject can be touched upon, I must omit many fascinating side issues, and all objective cases uncommented upon. A large number of cases themselves of peculiar interest. Further I exceedingly regret

that from the nature of my duties, consistent detailed examinations have not been possible. I feel confident however that the broad useful features of the changes in the blood of various diseases have been brought out and this encourages me to think, that even those pressed for time will not find similar work to be misspent time. I am further convinced that notwithstanding the vast number of workers at the subject at this time, the field for investigation is vaster still and promises to be a rich and fruitful ~~field~~ one.

We are first concerned with the number of white cells and their alterations. In most infective disorders the leucocytes are increased in number. There are however the very remarkable and consistent exceptions of Typhoid, Dysentery miliary tuberculosis, splenic anaemia Malaria & measles. Most important then is the clinical value of a blood count where we are in doubt as to whether a case is typhoid, meningitis or ulcerative Endocarditis. Several blood counts however must be made before a conclusion is arrived at. In Case No 11 of Enteral Fever Disease a Leucopenia was present even during a rigor in the one count made and in Case No 17 of Severe Malignant (ulcerative) Endocarditis which ended fatally a count of only 7500 WBC per c.m.m was found. On the other hand a very low count of 1600 in Case No 51 which was diagnosed as probably Typhus, made Typhoid more presumable. In Typhus unfortunately not sufficient statistics are at hand to determine the count of the white cells. This case post mortem proved to be typhoid. Case No 11 No 17 No 51

But even in diseases with a leucocytosis distinctions in the range of the leucocytosis are present among the various classes of cases. Presumably even the same organism can produce a different leucocytosis according to the site of the disease. The standard of leucocytosis for each disease must be arbitrarily fixed from the average count out of a large number of cases..

In Case no 14, a moribund patient, the diagnosis was probably a uremia, possibly some abdominal condition owing to dulness and tenderness in the left flank. The leucocytosis was 24,000 - too high for uremia possibly due therefore to pus accumulation in the left flank. Both these contingencies were considered - The post mortem result was an interesting corroboration of the main facts deduced from the count. It was a pyonephrotic abscess, with suppression of urine as a sequel. Thus in this case a slender doubt as to the uremia was confirmed by a white cell count and verified post mortem. no 14

A catarrhal appendicitis produces a lower leucocyte count than a purulent one. De Costa junior puts the highest limit for the former at 17,000. Cases no 4 & 5 showed counts of 7,500 & 11,000 & were clinically catarrhal appendicitis. Case no 6 was doubtful clinically - the leucocyte count showed 15,000 - At the operation a small abscess was found. Again a plastic peritonitis produces a low count - compared to a purulent peritonitis and this in Case no 13 proved of no small interest. In this case symptoms of a perf. gastric ulcer were present but the tender no 4 5 6 no 13

ness was very localised. A leucocytosis of 40,000 had its full verification on the operating table, for quite 1 pint of pus was evacuated from below the liver - it was an old perforated gastric ulcer. In this case the presumption from the blood count was that the condition present was very serious and probably there was a large pus accumulation.

That the standard of leucocytosis will be of clinical value in not a few cases receives illustration from the above. Nor is the standard for each disease the only matter deserving attention in leucocytosis to aid in diagnosis: The kind of leucocyte increased is very important. The lymphocytes may be in excess in the leucocytosis or the neutrophil polymuclears may predominate, and this distinction if a marked one, is of considerable significance in diagnosis.

A lymphocytosis is more frequent in children than in adults, and seems to be associated more with constitutional disorders, than with any other disease. A far more gross increase in the number of the lymphocytes is seen in Lymphatic Leukaemia and by this we come to a diagnosis.

The eosinophile polymuclear leucocyte may aid us in our diagnosis too. Its aid in judging of the progress of the disease will be considered later. As an example of its significance in diagnosis, in Trichinosis takes the first place for in this parasitic affection there is a great Eosinophilia. Case No 45 shows an increase No 45
which is consistent in all lymphogus cases. The blebs in this case chiefly contained eosinophile cells.

In case no 43 a marked Eosinophilia is present no 43.
and this is due to the round worm parasite
one of which she vomited on a date prior to the
blood count. The Eosinophilia is present in
other parasitic diseases too Eg. in Filaria Sanguinis
hominis. but not in Bilharzia Haematobium
nor in Oxyuris. as is seen in cases 46 & 46
44. The cells abnormal to the blood 44
may also serve to aid in diagnosis, and
in this category comes Myelocytes. which
are so largely present in Leucocythaemia.
In this disease the discrimination between
in ordinary Leucocytosis and an increase of
Myelocytes may not be very obvious.
"From this we can infer of the necessity of a
Differential Count, to allow of diagnosis.
Its value will be further seen in the Study
of several cases, I find it to be the most
accurate method to count the number of
cells per cubic millimetre. Very Specific
features are given to various diseases not by
the predominance of any one kind of white
cell but by the presence of all and their ratio.
to each other. It will be well then from this
point of view, to look at ordinary Leucocytosis and
Separate it into its two components roughly of
Neutrophile Leucocytes and Lymphocytes.
In case no 61 of Pseudo Leukaemia 12,000 Leucocytes 61
represent a Leucopenia of the neutrophils and a
high Lymphocytosis. In case no 22 of basal meningitis 22
in a baby a similar great Lymphocytosis is shown

In case 48 (chart) of rectal feeding the increase in lymphocytes is obvious In the typhoids 49 & 52 a similar Condition is found. Thus a high leucocyte Count does not signify much until the kinds of cells are differentiated - there may be no leucocytosis And yet owing to a decrease in the lymphocytes there may be present an absolute increase of neutrophils & also the neutrophil leucocytosis in a high count may be the only factor in the leucocytosis For this See the charts of Cases No 2, 25 & 26 & 27. Not infrequently however even in infective cases the lymphocytes share in constituting the leucocytosis, though probably this is of no significance as the ratio (percentage) between the two kinds of cells may still remain normal, the active neutrophil leucocytosis inducing a greater passive influx of lymphocytes. Thus there is a valuable clinical significance in the ratio of lymphocytes to neutrophils in a leucocytosis or leucopenia cannot be doubted. The exact nature of this has however not yet been established. The origin of the two kinds of cells is so wholly different that there must be a great distinction in their function - An increase of leucocytes of the neutrophil variety of sudden is probably the immediate result of a storage supply being utilized. But as Muir pointed out the amount of pus alone thrown off in certain suppurations, contain leucocytes far exceeding in amount the supply of the whole body. There is thus a rapid renewal of these cells the neutrophils from neutrophil myelocytes and the eosinophil from eosinophil myelocytes the place of origin being in

No 48
49
52
2
25
26
27

the bone marrow. These blood cells are answered and lymphocytes are not. Moreover lymphocytes are derived from tissues placed in most parts of the body in the form of lymphoid tissue, lymphatic glands and the Spleen. and they contain a Storage which needs no active renewal, for the demands made on it. A passive washing out of these tissues into the lymph channels & So into the blood is thus what probably occurs. With this in view a comparison of the charts of Cases No 61 with Case. No 2 25, 26 & 27 proves interesting. In the latter 61 2 25 26 27 Classes an active phagocytic function & Autolysis action is in demand. In the former a nutritional disorder & profound anaemia is present. A lymphocytosis will also be seen to have occurred the day after a gastro-Enterostomy in the Chart of Case No 30, and 30 after the injection of Coleys Fluid in the Chart of Case No 40. In the former however 40 the rise in lymphocytes is pari passu with the rise in neutrophils. That such a maintenance in the Ratio of Leucocytes of the Neutrophile and lymphocyte variety should occur in some Leucocytoses, and in the majority of Leucocytoses not cannot be explained. This Ratio however cannot be an accidental one for in Leucopenia it may be present, for example in Splenic Anaemia and in Case No 53, 53 the Chart of which will be referred to again. But as in Leucocytoses of the type Seen in Case 2 25 26 27, So in Leucopenia the lymphocyte

count may be normal; In typhoid this condition is actually present or approximately so.

The differential count materially aids in diagnosis not only but also in the prognosis and in observing the progress of the disease. The facts may be summarised briefly. Like a temperature in itself is no serious symptom unless too high, so a leucocytosis is the evidence of a healthy reaction against disease and is not of serious prognoses unless too high. A good leucocytosis like in Case no 2 is desirable. He passed through his pneumonia very satisfactorily. In Case No 13 where pus had accumulated in the lesser sac, the leucocytosis was high and at the same time of serious prognoses, for it indicated a serious lesion. In her case a low leucocyte count under the same conditions would not have been desirable. In venous hyaemia the result of lateral sinus disease, Case no 9, a low leucocyte 9
count is of bad significance. Case no 10 also a lateral 10
sinus disease with however meningitis added, had a low count. Both these died. In the ulcerative endo Carditis Case no 17. this serious prognosis in a low 17
count is manifested again. A low count may however be merely an incident in a disease, and not be maintained. A steady rise in the leucocytosis during the progress of the disease and later a steady fall as what we expect, but a long continued high leucocytosis is not significant of a good prognosis, and this is of greater value even than the temperature chart. A Pseudo crisis in a Pneumonia — Case no 2 does not appear the 2

the leucocytosis like a true crisis does.
A Sudden rise in the number of leucocytes during the course of a disease indicates some complication. This may even occur before a rise of temperature indicates it as Bowie points out in his observations on Scarlet fever. In typhoid the effect of complications are beautifully illustrated. Case no 52 - vide chart, 52.
Showed a low count and this was consistent with a diagnosis of typhoid of which there was some doubt.
The rise in the leucocyte count distinctly pointed to a complication. Bronchopneumonia though not obviously present, was presumably present. These inferences from the clinical features of the case and the leucocyte count were found to be correct, post-mortem.
A gradual return to the normal of the number of leucocytes is the sign of convalescence. In typhoid a gradual increase to the normal occurs. Case No 53 (chart) 53
illustrates this. His leucocyte count, not his red blood cell count, proved an absolute standard of his convalescence. As he improved his leucocytes increased the ratio between the neutrophils and lymphocytes being very constant. The disease here was tuberculosis of the intestines probably ulceration with Extreme Emaciation & pallor

The neutrophile count aids in prognoses, but the Eosinophile count is in no wise less significant. In all neutrophil leucocytosis the Eosinophil cells diminish in number or disappear, during convalescence they reappear and may increase in number & even remain so long after convalescence
This occurs in Scarlet fever, See also cases No 60 No 2 & 26 (charts.). This delicate reaction

of the Eosinophiles is a very constant and valuable feature of differential counts. In Leucocythaemia (myelogenic) this relationship to the neutrophiles is broken

In prognosis we must also consider the myelocytes. Their presence is unfavourable; In Leucocythaemia it is best to study them in their relations to the other three types of cells, dealt with above - The Lymphocytes, neutrophiles and Eosinophiles. Vide Charts of Case 67. 2067

All the white cells are increased - chiefly the myelocytes and Eosinophils. All these are in direct ratio to Each other, so that unlike other diseases the Eosinophil cells are not in inverse ratio to the Neutrophils, and Simulate parasitic diseases in this respect. The myelocytes are increased 100 fold to an increase of 30 fold of the neutrophils, and Equal in number all the other Constituents together. In addition there are Eosinophil myelocytes which in this disease are relative to the neutrophil myelocytes

As the ~~Eosinophil~~ Leucocytes are to the neutrophil They soon disappear from calculation as the myelocytes fall. An interesting stage in the progress of the disease is shown where the Leucocytes count

Crosses above the ~~lymphoc~~ myelocyte line.

Of great interest no doubt as the rapid diminution of myelocytes is, the change in their character is no less so. When the cells fell to 40,000

the myelocytes were of the large appearance of Neutrophe. Leucocytes except in the form of their nuclei. There was however but little difficulty in differentiating these. and here let me point out the remarkable

Change in detail in Digestive Leucocytosis.
The increase from 40,000 to 56,000 was chiefly by means of myelocytes. For the changes in the Character of the myelocytes before & after treatment See "Drawings" The result of a relapse in this case during the 3 wks after the lowest count is seen in the chart. In concluding a review of this case of Leucocythaemia the remarkable Constancy in the ratio of the various Elements, Even though so numerous & complicated, must be Emphasized.

It would appear that Each variety of cells has its own Specific function and that the control of their ratios to Each other is under a very uniform law.

It is well to take the red cells with this case, and to consider the changes in red cells in disease as a whole later on.
There is an inverse ratio between the number of red cells and the nucleated red cells. This ratio may be broken at intervals, showing a great increase in nucleated red cells, to pass away as soon again. A very similar condition occurs in the case of Pseudo Leukaemia.

In conjunction with the Leucocythaemia it is well to take Case No 61 (vide charts) which No 61
is an Example of an intercurrent Secondary Anaemia in a boy aged 2. Rhachitic & Syphilitic in origin.
Pseudo Leukaemia infantum is the term applied to this Anaemia. It consists of a profound Anaemia and a Leucocytosis chiefly of lymphocytes there being in fact a Leucopenia of the neutrophile.
The low red cell count of 780,000 per c.mm.

would account for the large number of nucleated red cells present. The nuclei were often free from the cells. In many they were double & not infrequently indented. The ~~M~~ most of red cells can be called the Normoblast. The Haemoglobin Equivalent for the red cell is $\frac{1}{1}$ and remained so through out the disease. The other abnormal element is the myelocytes. They too were numerous and contained a considerable proportion of large oval cells with oval nuclei, faintly stained & non granular - too large to be classified among the lymphocytes (see Drawing)

A normal proportion of transitional cells was present. The great rise in the lymphocytes on two occasions cannot be explained though the second rise might have been due to the severe epistaxis that occurred on the day previously. The ratio between the red cells and nucleated reds is an inverse one, up to one point, when a large increase of nucleated reds occurs.

In both the foregoing cases the white cells were important, chiefly so in the Leukaemia, and in both the red cells showed profound changes, chiefly in the latter. We are now in a position to look briefly at the changes in the red cells in disease

Not only do varieties of white cells maintain definite ratios to each other even though comingled in one medium, but also the relations between white & red cells are ~~constant~~ of interest. In destruction or loss of red cells a leucocytosis occurs, but in nothing further can we trace a correspondence in reaction. Severe infective disorders will cause

a profound anaemia and characteristically
So in some diseases. Yet the white & red cells
must remain in ~~an~~ altogether Separate Categories
in Studying changes in the blood. We have
Seen the progress of a case (no 53) to be identical
with the increase of white cells, the red cells
remaining fairly constant. We will now observe
a class of case in which the leucocytes are no
guide to the character or progress of the disease.
This disease is called pernicious anaemia,
and in it the red cells form the basis of
all the observations. They diminish more or less
profoundly in number, and change more markedly
even in shape & character. A neutrophil leucocytosis no 60
is present as a rule (vide Chart of Case 60),
and a slight lymphocyte increase. A toxin
has acted on the red cells. A new toxin acts
- namely Arsenical poisoning - and as ever the
other variety of cell of the blood reacts - a neutrophil
leucocytosis occurs. This can be compared to
a Leukopenia in typhoid followed by a neutrophil
leucocytosis on a complication arising.
The red cells as improvement occurs rise
in number, the poikilocytosis diminishes, the microcytes
disappear. So marked indeed is this change
that the examination of a film only will reveal
what date to ascribe it to. The ~~Chart~~ Comparison
with the diminution in number of myelocytes in
Leucocythaemia and their remarkable change in
character (vide Drawing). The nucleated
red cells disappear.

Profound Anoemia is well characterised in Case
no 62. The origin of it was probably post- 62
partum. Her red cell fell as low as 730,000.
Poikilocytosis & microcytosis was most marked.
And the number of nucleated reds exceeded that
of the pernicious anoemia.

Case no 17 will also bear contrast with a pernicious 17
Anoemia in character. The bad prognosis in the
low leucocyte count could not have been verified better
than by an examination of the red cells. Poikilocytosis
was extreme and most characteristic was the large
number of nucleated red cells per c.mm. these were chiefly
Megaloblastic in type with large clear nuclei (Vide drawing)

In 'Burns' we find an interesting
supplement to the study of changes in the blood
red cells. Cases 69 - 74 (melaena) all 69 - 74
examined after Extensive burns when in a state
of collapse & cyanosis, showed a high leucocytosis
of 20 - 30,000. and a red b. cell count of 6,000 000
or more. A fall in the leucocyte count follows
in a day or two (Case 74) and then a high
rise as Suppuration goes on. No Eosinophiles are
present. The red cells in Case 73 showed 73.
a condition which accounted for the Haemoglobinuria
present. Her urine was portwine red, & full
of a rusty brown sediment - largely made
up of tubule casts. There were no red cells
present but the albumin was very abundant.

The film preparation showed most remarkable
changes in the Size of cells, the finest shreds of cell
tissue lay mingled with microcytes of varying size

There were but few normal cells. Scattered among the myelocytes were very conspicuous and deeply stained ~~Eosinophile~~ small red cells. These were strikingly obvious. The patient died within 36 hrs of the accident. A profound haemolysis had occurred in the blood. Case 72, a fatal burn also showed this condition, perhaps a little less marked but essentially the same in every detail. No poikilocytosis was present. The microscopic picture in no case simulates that of pernicious anaemia. (see drawings) 72

How did this haemolysis occur? more probably through a toxin of haemolytic power than through anisotony. Viscosity of the blood could be very readily reduced by the fluids so greedily swallowed. The cause then is probably a toxin; the prognosis fatal.

In two Purpuras examined, no change in the blood cells was found - one of these was of several years standing - a chronic purpura. A case of Henoch's purpura in a boy who made a very satisfactory recovery as to be seen in Case No 32 - the chart shows well the high leucocytosis & steady fall during convalescence. The few myelocytes present soon disappeared. No eosinophiles were present. The clinical appearance was that of septic fever - a culture made from blood drawn from the vein, proved negative, even though I used several culture media. 32

In closing let me point out the result of operations. The charts of Cases 25, 26, 27 & 30 are self explanatory. A post operative Leucocytosis occurs - a rapid return to normal of Hb and. Case No 24 showed unsatisfactory progress & was not improved.

Iodine in the form of Coleys fluid, after large & repeated injections produced Leucopenia. This was in a case of Sarcoma of the orbit - Case 40

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Literature used chiefly.

Clinical Examination of Blood - Cabot.

Histology of the blood Ehrlich & Lazarus

Robert Muir Relations of the Bone marrow & Leucocyte production and Leucocytosis

Articles on Leucocythaemia

Marrow in pernicious anaemia

Locke & Cabot: On Iodothrixin in Journal of Medical Research - January

Bowie: Leucocytosis of Scarlet Fever & its complication Journal of Pathology & Bacteriology (March)

Lovell Gulland: Blood in Febricases British med. Journal April 1901

Rogers: Blood Changes in Typhoid & Malaria (Article)

V. Jakoch: Clinical Diagnosis.

J.S Fowler: On Pseudo Leukaemic Infantum (Article)