# BLOOD COUNTS IN EXPERIMENTAL POLIOMYELITIS IN THE MONKEY.

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When poliomyelitic virus has once been established in the monkey, it becomes more virulent for this animal by repeated passage.[1] Hence the virus used in experimental work usually brings about a severe form of the disease and high death rate. Occasionally an animal survives the stage of complete prostration if carefully attended and recovers with residual contractures. Experimental poliomyelitis in the monkey, then, is comparable with the severer forms in man, and observations on the variation in leucocyte count in the circulating blood would therefore be expected to yield more nearly uniform results than studies on human cases. In the latter there are many factors of difference in reaction and resistance, age and virulence of the virus, which might contribute to variation. Moreover, opportunities for observations during the incubation period in human cases are rare.

It is generally accepted that abnormal white blood counts are constantly found in poliomyelitis, but opinion is divided on the characteristics of this change.

Müller[2] asserts that a distinct leucopenia with a relative lymphocytosis is characteristic and pathognomonic of the febrile stage, while La Fétra[3] had previously described a moderate leucocytosis as being characteristic of the acute stage in human beings.

Gay and Lucas[4] summarize their blood findings as follows: "The acute stage of anterior poliomyelitis, as it occurs in human beings, and as it is produced experimentally in monkeys, is characterized by the occurrence of a distinct leuko-

[1] Flexner, S., Clark, P. F., and Amoss, H. L., *J. Exp. Med.*, 1914, xix, 195.

[2] Müller, E., Die spinale Kinderlähmung, Berlin, 1910.

[3] La Fétra, L. E., *Arch. Pediat.*, 1909, xxvi, 328.

[4] Gay, F. P., and Lucas, W. P., *Arch. Int. Med.*, 1910, vi, 330.

penia. The differential count shows a relative increase in number of eosinophils and lymphocytes."

Peabody, Draper, and Dochez[5] found in human cases a constant and marked leucocytosis. They also found a constant increase in polymorphonuclear cells of 10 to 15 per cent and a diminution of lymphocytes of 15 to 20 per cent.

## OBSERVATIONS.

Blood counts were made on six series of monkeys as follows: Series I, 40 normal monkeys for comparison (Table I); Series II, 4 monkeys already prostrate from experimental poliomyelitis (Table II); Series III, 12 monkeys during the incubation period, later developing the disease; Series IV, 5 monkeys which received the virus but did not develop the disease; Series V, 4 monkeys during the period of recovery from the acute stage; Series VI, 5 monkeys which had passed through the attack and recovered with residual paralyses.

In order to reduce the hourly variations in the blood counts the samples were collected at about the same time on the days of observation between 10.30 and 11.30 a.m.

*Series I.*—121 counts were made on 40 healthy, adult monkeys (*Macacus rhesus*). Averages of all counts are recorded in Table I.

TABLE I.

*Average of 121 White and Differential Blood Counts on 40 Normal Monkeys.*

| White cells per c.mm. | Lymphocytes. | | Polymorphonuclear leucocytes. | | | Large mononuclear and transitional leucocytes. | Total lymphocytes. | | Total polymorphonuclear neutrophilic leucocytes per c.mm. |
|---|---|---|---|---|---|---|---|---|---|
| | Small. | Large. | Neutrophilic. | Eosinophilic. | Basophilic. | | | | |
| | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | | |
| 22,181 | 47.5 | 6.2 | 41.1 | 4.1 | 0.4 | 0.6 | 53.7 | 11,815 | 9,116 |

*Series II.*—Seven counts on four monkeys paralyzed as a result of experimental inoculation with the virus of poliomyelitis are recorded in Table II.

[5] Peabody, F. W., Draper, G., and Dochez, A. R., A clinical study of acute poliomyelitis, Monograph of The Rockefeller Institute for Medical Research, No. 4, New York, 1912, 97.

TABLE II.

*White and Differential Blood Counts on Monkeys Prostrate after Poliomyelitic Infection.*

| Monkey No. | Length of time after inoculation. | Day of prostration. | White cells per c.mm. | Lymphocytes. | | Polymorphonuclear leucocytes. | | | Large mononuclear and transitional leucocytes. | Total lymphocytes. | | Total polymorphonuclear neutrophilic leucocytes per c.mm. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Small. | Large. | Neutrophilic. | Eosinophilic. | Basophilic. | | | | |
| | *days* | | | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* | | |
| 1 | 17 | 2 | 8,875 | 13.7 | 6.3 | 74.7 | 2.0 | 0.0 | 3.3 | 20.0 | 1,775 | 6,630 |
| 2 | 37 | * | 9,150 | 20.0 | 3.3 | 76.0 | 0.3 | 0.0 | 0.3 | 23.3 | 2,132 | 6,954 |
| | 38 | 1 | 8,275 | 24.3 | 2.7 | 70.0 | 3.0 | 0.0 | 0.0 | 27.0 | 2,234 | 5,793 |
| | 41 | 4 | 4,900 | 21.6 | 3.3 | 73.7 | 0.7 | 0.0 | 0.7 | 25.0 | 1,225 | 3,611 |
| | 47 | 10 | 4,675 | 28.3 | 18.7 | 53.0 | 0.0 | 0.0 | 0.0 | 47.0 | 2,197 | 2,478 |
| 3 | 10 | 2 | 17,550 | 15.7 | 1.7 | 82.7 | 0.0 | 0.0 | 0.0 | 17.4 | 3,054 | 14,514 |
| 4 | 10 | 3 | 21,600 | 14.0 | 5.7 | 80.3 | 0.0 | 0.0 | 0.0 | 19.7 | 4,255 | 17,345 |

* Almost prostrate; both legs flaccid; left arm and back weak.

Monkey 1 of this series received the virus by the nasal route. An intraspinal injection of 2 cc. of normal horse serum had been given on the day preceding the application of the virus to the nasal mucous membrane. After 10 days the monkey became excitable, after 11 days ataxic, and on the 15th day it became prostrate. The blood count was made on the 17th day after infection, which was the 8th day of the disease and the 2nd day after the monkey had become completely prostrated. Death occurred on the 21st day, and autopsy showed well defined lesions of poliomyelitis.

Monkey 2 was inoculated intracerebrally with an incubated mixture of 0.2 cc. of a Berkefeld filtrate of an active glycerolated virus and 2 cc. of human immune serum. The incubation period was unusually long, *viz.* 30 days; the course of the disease was also unusually slow, since the animal did not become prostrate until the 38th day after injection. When the first count was made on the 37th day after injection both legs were flaccid, and the left arm was weak. On the following day, when the animal became prostrate, another count was made. Other counts were made on the 41st and 47th days after injection, which were the 11th and 17th days of the disease. The animal succumbed on the 49th day, and microscopic lesions of poliomyelitis were found in the brain and cord.

Monkeys 3 and 4 were inoculated intracerebrally with an incubated mixture of 0.2 cc. of a Berkefeld filtrate of a 5 per cent suspension of an active glycerolated virus and 2 cc. of streptococcus immune rabbit serum 10 days before the blood

counts were made. Monkey 3 had been prostrate 2 days and Monkey 4 3 days at this time. Both animals were etherized on the 14th day, and autopsy showed characteristic lesions of poliomyelitis.

*Series III.*—Blood counts were made on twelve monkeys before inoculation with active virus, during the incubation period, and during the acute stage of poliomyelitis. Observations were made at intervals until the animals were killed by etherization or died of respiratory paralysis. All injections of the virus were intracerebral except in Monkeys 8 and 9, which received the virus by the nasal route on the day following an intraspinal injection of 2 cc. of normal horse serum. Nos. 5, 6, and 7 were from the Philippines, monkeys apparently closely similar to *Macacus cynomolgus*. The remainder were *Macacus rhesus*. The results are recorded in Table III. The variations in the circulating lymphocytes in Monkeys 5, 6, 7, and 8 are graphically represented in Text-fig. 1, *a*, *b*, *c*, and *d*, those of Monkeys 9 to 16 in Text-figs. 2 to 4.

*Series IV.*—Counts on five monkeys (Nos. 17 to 21), which received active virus by several routes but which did not develop the disease, are tabulated in Table IV. Fresh virus was given to Monkey 17 by mouth, to Monkey 18 by means of a nasal plug, to Monkey 19 by intrasciatic injection, and to Monkeys 20 and 21 by intracerebral inoculation.

*Series V.*—A summary of counts at intervals on monkeys during the acute stage and when partial or complete recovery had taken place is given in Table V. The fluctuations of the circulating lymphocytes are graphically represented in Text-figs. 5 and 6.

Monkey 22 of this series was injected intracerebrally with cultivated virus, first generation,[6] 4 days before the first blood count was made. At this time convulsions and ataxia were noted. On the 7th day after inoculation, when the third white blood count was made, the animal was partially paralyzed, but never became prostrate. 15 days after symptoms were first noted, at the time of the last blood count, the animal had almost completely recovered.

Monkey 23 was exposed to x-rays during the interval between the first and second blood counts, and the blood exhibited the characteristic lymphocytic drop.[7] Seven doses of unfiltered x-rays of 6 Holzknecht units each were given over

[6] Smillie, W. G., *J. Exp. Med.*, 1918, xxvii, 319.

[7] Taylor, H. D., Witherbee, W. D., and Murphy, Jas. B., *J. Exp. Med.*, 1919, xxix, 53.

TABLE III.

*Blood Counts on Monkeys during the Incubation Period after Injections of Poliomyelitic Virus.*

| Monkey No. | Day of observation. | Length of time after inoculation. | Day of symptoms. | Total lymphocytes. | | Total polymorphonuclear neutrophilic leucocytes. | |
|---|---|---|---|---|---|---|---|
| | | *days* | | *per cent* | | *per cent* | |
| 5* | 1 | | | 24.0 | 6,780 | 74.7 | 21,103 |
| | 3 | 2 | | 33.4 | 6,430 | 66.0 | 12,705 |
| | 4 | 3 | | 47.7 | 7,966 | 51.7 | 8,643 |
| | 6 | 5 | 1 | 12.7 | 2,937 | 86.7 | 20,049 |
| | 7 | 6 | 2 | 44.7 | 9,834 | 54.3 | 11,946 |
| | 8 | 7 | 3 | 38.0 | 6,983 | 61.0 | 11,204 |
| | 9 | 8 | 4 | 20.7 | 5,988 | 79.3 | 22,938 |
| | 11 | 10 | 6 | 15.3 | 4,777 | 85.3 | 26,635 |
| | 14 | 13 | 9 | 12.3 | 3,795 | 85.3 | 26,465 |
| 6* | 1 | | | 22.0 | 6,067 | 77.3 | 21,223 |
| | 3 | 2 | | 27.0 | 3,692 | 72.3 | 9,887 |
| | 4 | 3 | | 11.7 | 2,533 | 88.3 | 19,117 |
| 7* | 1 | 3 | | 34.7 | 10,315 | 61.3 | 18,221 |
| | 2 | 4 | | 41.0 | 4,797 | 47.7 | 5,581 |
| | 4 | 6 | 1 | 10.0 | 1,948 | 90.0 | 17,528 |
| 8† | 1 | | | 49.7 | 8,225 | 47.3 | 7,828 |
| | 2 | | | 51.0 | 6,464 | 45.3 | 5,742 |
| | 5 | | | 38.0 | 6,441 | 58.3 | 9,882 |
| | 9 | 4 | | 60.7 | 8,270 | 38.3 | 5,218 |
| | 11 | 6 | | 15.7 | 4,887 | 84.3 | 26,238 |
| | 13 | 8 | 1 | 42.3 | 7,254 | 56.0 | 9,604 |
| | 14 | 9 | 2 | 30.0 | 5,670 | 67.3 | 12,720 |
| 9† | 1 | | | 47.7 | 9,922 | 49.7 | 10,347 |
| | 12 | 2 | 11 | 32.0 | 5,040 | 66.0 | 9,735 |
| | 13 | 3 | 12 | 38.4 | 5,126 | 60.7 | 13,230 |
| | 14 | 4 | 13 | 27.4 | 4,226 | 72.0 | 11,106 |
| | 15 | 5 | 14 | 40.7 | 4,701 | 58.0 | 6,699 |
| | 16 | 6 | 15 | 30.0 | 3,833 | 68.7 | 8,776 |
| | 18 | 8 | 17 | 30.0 | 4,583 | 70.0 | 10,693 |
| | 19 | 9 | 18 | 16.0 | 2,524 | 83.7 | 13,204 |

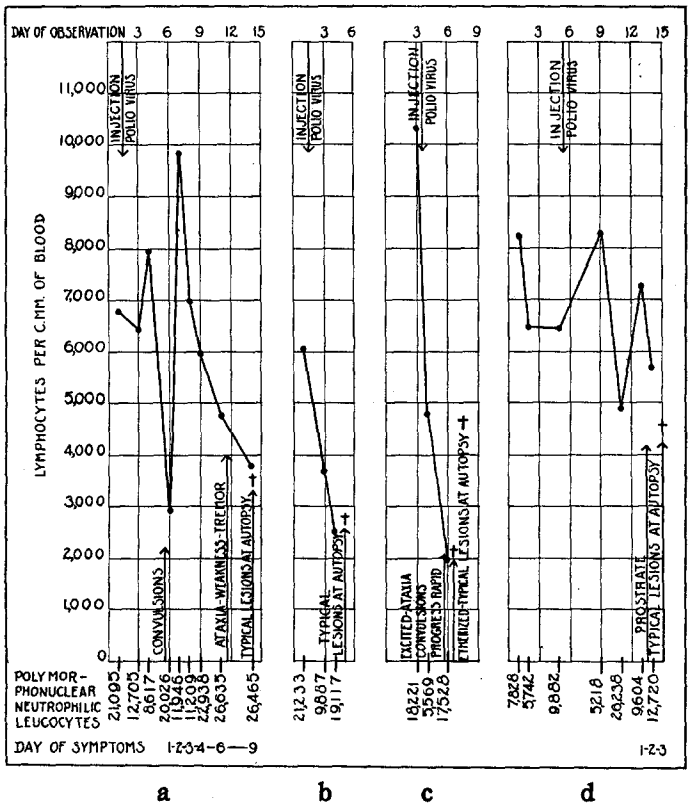
* Philippine monkey.

† Nasal route of infection. Previous intraspinal injection of 2 cc. of normal horse serum.

TABLE III—*Concluded.*

| Monkey No. | Day of observation. | Length of time after inoculation. | Day of symptoms. | Total lymphocytes. | | Total polymorphonuclear neutrophilic leucocytes. | |
|---|---|---|---|---|---|---|---|
| | | *days* | | *per cent* | | *per cent* | |
| 10 | 1 | 4 | | 32.0 | 10,696 | 54.7 | 18,214 |
| | 3 | 6 | | 51.5 | 15,939 | 47.1 | 14,578 |
| | 5 | 8 | 1 | 36.7 | 4,936 | 62.0 | 8,339 |
| | 6 | 9 | 2 | 23.0 | 3,835 | 73.7 | 12,290 |
| | 7 | 10 | 3 | 32.0 | 4,304 | 64.7 | 8,702 |
| | 8 | 11 | 4 | 29.0 | 3,567 | 68.7 | 8,450 |
| | 9 | 12 | 5 | 62.0 | 6,417 | 37.3 | 3,861 |
| | 10 | 13 | 6 | 33.7 | 4,457 | 66.3 | 8,768 |
| 11 | 1 | 2 | | 46.7 | 12,117 | 49.3 | 12,793 |
| | 2 | 3 | | 47.7 | 9,051 | 46.7 | 8,861 |
| | 5 | 6 | | 44.0 | 8,217 | 53.7 | 10,029 |
| | 6 | 7 | 1 | 13.0 | 3,452 | 86.7 | 23,019 |
| 12 | 1 | | | 57.7 | 15,348 | 34.0 | 9,044 |
| | 3 | 2 | | 60.0 | 10,740 | 37.0 | 6,623 |
| | 4 | 3 | | 78.0 | 11,661 | 19.0 | 2,841 |
| | 5 | 4 | | 69.3 | 19,477 | 28.3 | 3,870 |
| | 7 | 6 | | 64.4 | 13,347 | 35.3 | 7,316 |
| | 8 | 7 | 1 | 19.7 | 6,161 | 79.7 | 24,926 |
| 13 | 1 | | | 37.3 | 12,476 | 62.3 | 20,839 |
| | 3 | 2 | | 48.7 | 10,373 | 49.3 | 10,501 |
| | 6 | 5 | | 70.7 | 9,297 | 28.7 | 3,744 |
| | 7 | 6 | | 29.7 | 14,323 | 69.3 | 23,420 |
| | 8 | 7 | | 36.7 | 5,633 | 63.0 | 9,671 |
| | 9 | 8 | 1 | 18.7 | 3,675 | 81.0 | 15,917 |
| 14 | | | | 38.7 | 9,298 | 57.7 | 13,862 |
| | 8 | 7 | | 22.4 | 3,489 | 76.7 | 11,946 |
| | 11 | 10 | 2 | 10.0 | 2,373 | 89.3 | 21,186 |
| | 12 | 11 | 3 | 20.0 | 2,970 | 80.0 | 11,880 |
| | 13 | 12 | 4 | 14.3 | 2,431 | 82.3 | 13,991 |
| 15 | 1 | 3 | | 58.7 | 12,151 | 40.3 | 8,342 |
| | 4 | 6 | | 46.7 | 17,046 | 51.7 | 18,871 |
| | 7 | 9 | 2 | 24.7 | 3,557 | 72.3 | 10,411 |
| | 8 | 10 | 3 | 17.7 | 3,615 | 79.3 | 16,197 |
| 16 | 1 | 4 | | 45.0 | 8,179 | 53.3 | 9,687 |
| | 5 | 8 | 1 | 22.0 | 2,794 | 76.7 | 9,741 |
| | 6 | 9 | 2 | 14.7 | 2,132 | 83.7 | 12,137 |
| | 7 | 10 | 3 | 13.0 | 1,940 | 86.3 | 12,945 |
| | 8 | 11 | 4 | 11.0 | 2,540 | 87.0 | 20,097 |

a period of 6 days, the dorsal and ventral surfaces of the body being alternately exposed. Each dose was governed by the following factors: spark-gap 3 inches, milliamperes 10, distance from the target of the Coolidge tube to the skin 12 inches, and time of exposure 4 minutes. After these treatments the animal was inoculated intracerebrally with active virus and became completely prostrate

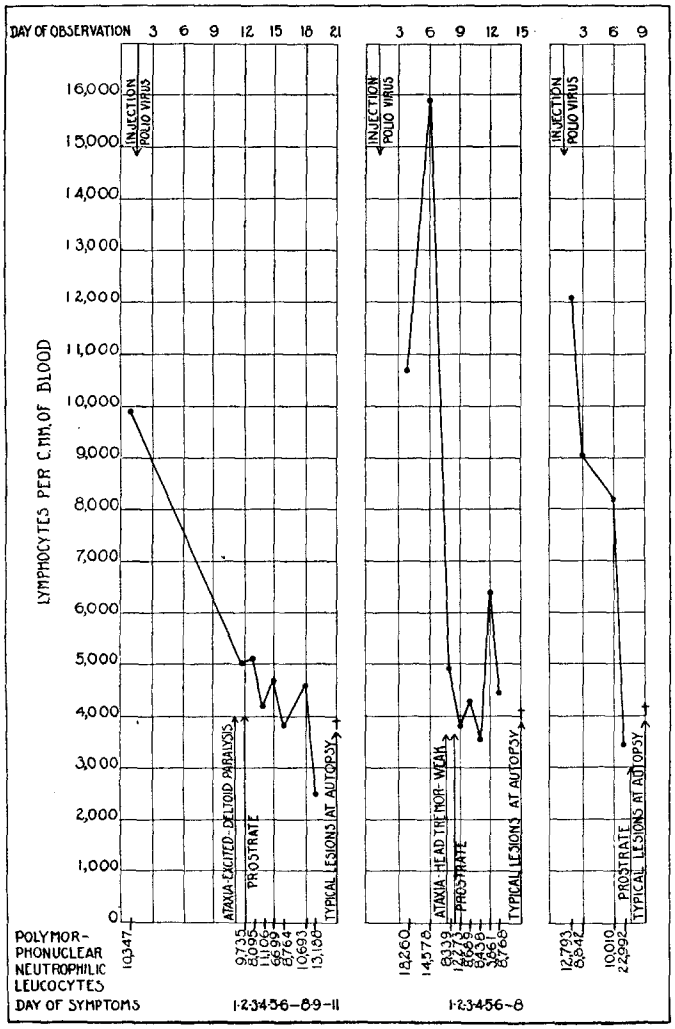



TEXT-FIG. 1, *a*, *b*, *c*, and *d*. Lymphocyte curve of Monkeys 5, 6, 7, and 8 (Table III).

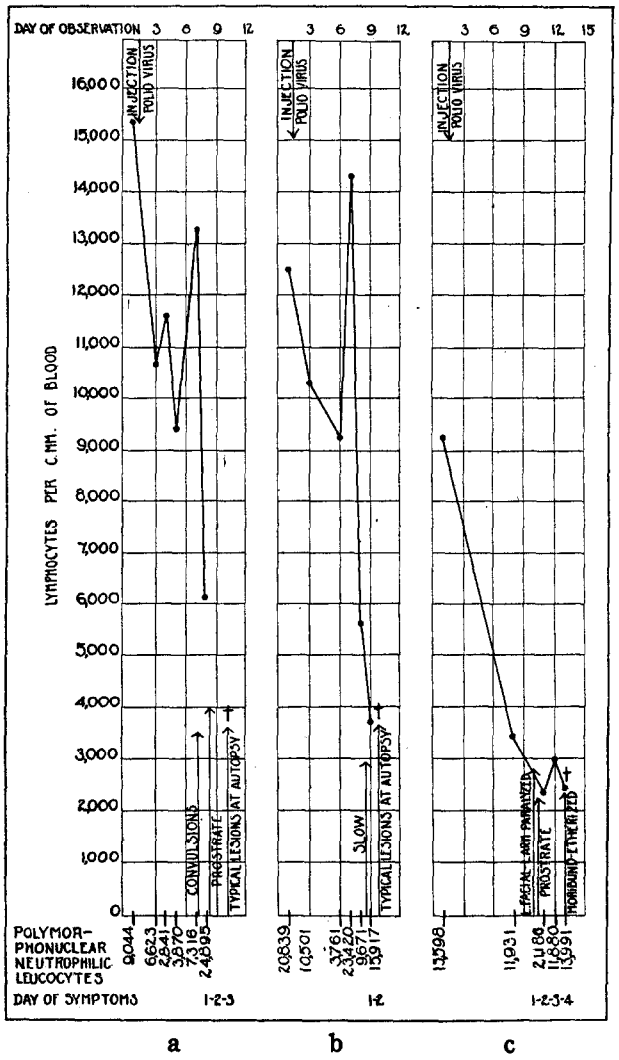
8 days later. The animal recovered with marked residual paralysis of both legs. Counts were made on the 59th day of observation, 45 days after prostration, and on the 76th day of observation.

Counts were made on Monkey 24 before injection and 5 days afterward. The animal was prostrate on the 12th day. Counts were made on the 16th, 28th, and 172nd days.

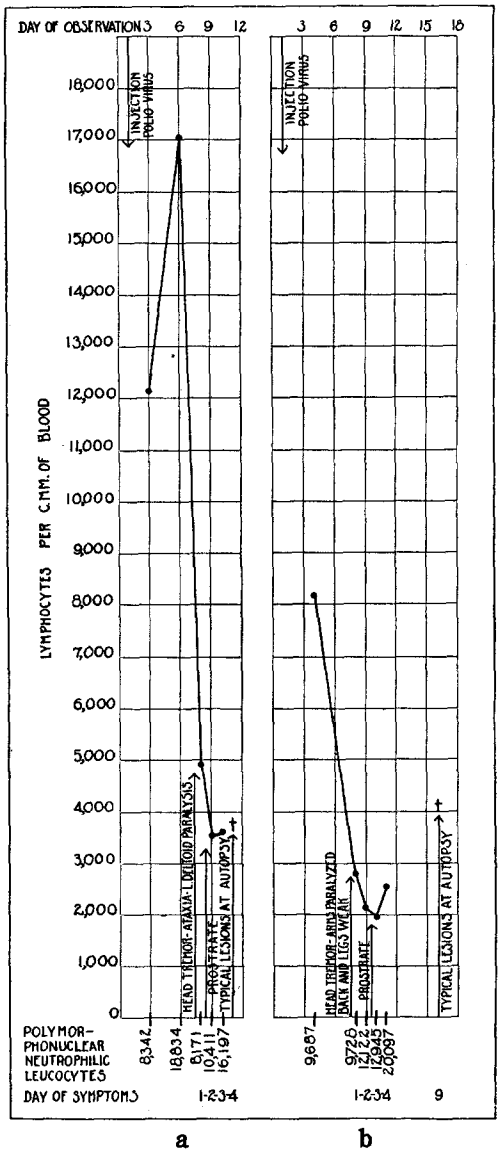
The first count was made on Monkey 25, 16 days after prostration, and the subsequent lymphocytic curve was followed for 22 days, during recovery with residual paralysis.




TEXT-FIG. 2, *a*, *b*, and *c*. (*a*) Lymphocyte curve of Monkey 9 (Table III). (*b*) Lymphocyte curve of Monkey 10 (Table III). (*c*) Lymphocyte curve of Monkey 11 (Table III).




TEXT-FIG. 3, *a*, *b*, and *c*. (*a*) Lymphocyte curve of Monkey 12 (Table III). (*b*) Lymphocyte curve of Monkey 13 (Table III). (*c*) Lymphocyte curve of Monkey 14 (Table III).




TEXT-FIG. 4, *a* and *b*. (*a*) Lymphocyte curve of Monkey 15 (Table III). (*b*) Lymphocyte curve of Monkey 16 (Table III).

TABLE IV.

*Blood Counts on Monkeys Which Received Virus but Did Not Develop Symptoms.*

| Monkey No. | Day of observation. | Length of time after inoculation. | Day of symptoms. | Total lymphocytes. | | Total polymorphonuclear neutrophilic leucocytes. | |
|---|---|---|---|---|---|---|---|
| | | *days* | | *per cent* | | *per cent* | |
| 17 | 1 | | | 41.0 | 9,615 | 57.0 | 12,367 |
| | 6 | 5 | | 51.0 | 8,096 | 46.3 | 7,360 |
| | 13 | 12 | | 31.4 | 4,561 | 64.7 | 9,398 |
| | 23 | 22 | | 54.4 | 8,772 | 35.0 | 5,644 |
| | 37 | 36 | | 46.7 | 8,556 | 45.0 | 8,556 |
| 18 | 1 | | | 50.7 | 11,205 | 40.3 | 8,906 |
| | 3 | 1 | | 56.4 | 9,292 | 39.7 | 6,541 |
| | 6 | 4 | | 49.3 | 8,849 | 47.0 | 8,437 |
| | 8 | 6 | | 55.0 | 16,871 | 42.3 | 12,976 |
| | 11 | 9 | | 68.3 | 16,871 | 28.3 | 6,055 |
| | 18 | 16 | | 56.7 | 17,393 | 39.7 | 12,178 |
| | 27 | 25 | | 55.4 | 11,426 | 43.0 | 8,869 |
| | 32 | 30 | | 59.4 | 15,622 | 38.7 | 10,178 |
| | 35 | 33 | | 47.7 | 9,922 | 49.7 | 10,347 |
| 19 | 1 | | | 43.3 | 9,959 | 51.7 | 11,891 |
| | 6 | 4 | | 54.0 | 10,139 | 42.0 | 7,886 |
| | 8 | 6 | | 42.7 | 7,163 | 54.7 | 9,178 |
| | 11 | 9 | | 56.7 | 9,242 | 39.0 | 6,357 |
| | 13 | 11 | | 50.0 | 7,188 | 43.3 | 6,224 |
| | 21 | 19 | | 54.7 | 6,687 | 43.0 | 5,257 |
| | 31 | 29 | | 43.0 | 7,740 | 56.3 | 10,134 |
| | 39 | 37 | | 54.7 | 8,971 | 43.0 | 7,052 |
| 20 | 1 | | | 66.0 | 16,320 | 23.7 | 5,824 |
| | 3 | 2 | | 71.3 | 11,889 | 26.3 | 4,386 |
| | 4 | 3 | | 72.0 | 13,392 | 21.7 | 4,036 |
| | 5 | 4 | | 66.0 | 9,719 | 27.7 | 4,079 |
| | 7 | 6 | | 64.0 | 14,848 | 30.3 | 7,030 |
| | 8 | 7 | | 62.0 | 10,804 | 31.7 | 5,524 |
| | 9 | 8 | | 56.7 | 9,667 | 34.7 | 5,916 |
| | 11 | 10 | | 58.0 | 8,715 | 36.7 | 5,514 |
| | 15 | 14 | | 74.3 | 16,718 | 20.3 | 4,568 |
| | 18 | 17 | | 59.3 | 10,674 | 36.0 | 6,480 |
| | 22 | 21 | | 66.7 | 14,724 | 25.0 | 5,519 |
| | 26 | 25 | | 74.3 | 13,764 | 18.0 | 3,334 |
| | 33 | 32 | | 79.7 | 15,362 | 16.3 | 3,142 |
| | 36 | 35 | | 72.3 | 16,792 | 23.3 | 5,178 |

TABLE IV—*Concluded.*

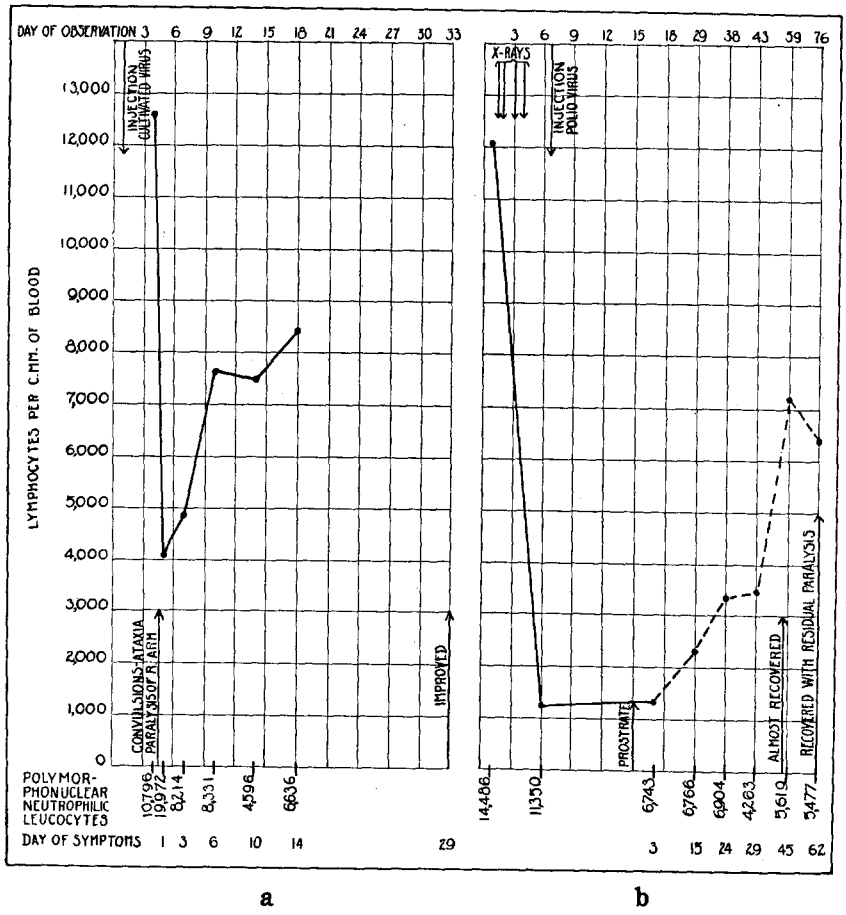
| Monkey No. | Day of observation. | Length of time after inoculation. | Day of symptoms. | Total lymphocytes. | | Total polymorphonuclear neutrophilic leucocytes. | |
|---|---|---|---|---|---|---|---|
| | | *days* | | *per cent* | | *per cent* | |
| 21 | 1 | | | 61.0 | 11,087 | 33.0 | 5,998 |
| | 2 | 1 | | 30.7 | 4,313 | 66.3 | 9,315 |
| | 7 | 6 | | 45.3 | 6,670 | 47.7 | 6,024 |
| | 8 | 7 | | 62.3 | 7,507 | 35.0 | 4,218 |
| | 11 | 10 | | 60.3 | 9,105 | 36.7 | 5,542 |
| | 14 | 13 | | 67.3 | 11,592 | 30.7 | 5,288 |
| | 17 | 16 | | 76.7 | 10,086 | 22.7 | 2,985 |
| | 21 | 20 | | 64.0 | 10,304 | 34.0 | 5,474 |

TABLE V.

*Blood Counts on Monkeys Observed during the Process of Recovery from Poliomyelitis.*

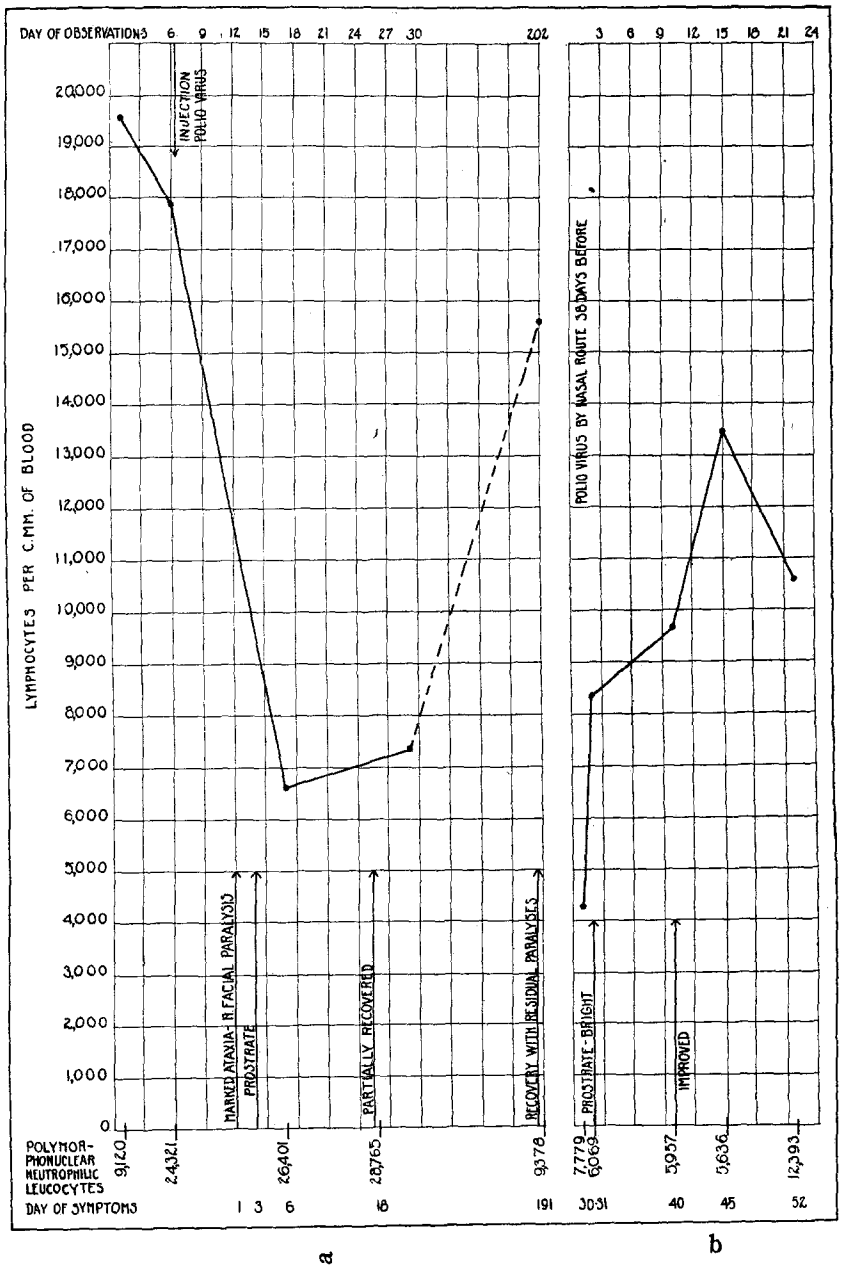
| Monkey No. | Day of observation. | Length of time after inoculation. | Day of symptoms. | Total lymphocytes. | | Total polymorphonuclear neutrophilic leucocytes. | | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | | *days* | | *per cent* | | *per cent* | | |
| 22 | 1 | 4 | 1 | 55.3 | 12,619 | 45.7 | 10,820 | Convulsions; ataxia. |
| | 2 | 5 | 2 | 16.7 | 4,087 | 81.7 | 11,996 | |
| | 4 | 7 | 4 | 36.3 | 4,864 | 61.3 | 8,214 | Paralyzed but not prostrate. |
| | 7 | 10 | 7 | 29.3 | 7,640 | 70.3 | 18,331 | |
| | 11 | 14 | 11 | 62.3 | 7,476 | 38.3 | 4,596 | |
| | 15 | 18 | 15 | 55.0 | 8,429 | 43.3 | 6,636 | Almost recovered. |
| 23 | 1 | | | 45.0 | 12,071 | 54.0 | 14,486 | X-rayed after count. |
| | 6 | | | 9.0 | 1,231 | 83.0 | 11,350 | |
| | 17 | 11 | 3 | 16.0 | 1,332 | 81.0 | 6,743 | Prostrate 3 days. |
| | 29 | 23 | 15 | 23.3 | 2,318 | 68.0 | 6,766 | Partly recovered. |
| | 38 | 32 | 24 | 29.3 | 3,355 | 60.3 | 6,904 | |
| | 43 | 37 | 29 | 42.3 | 3,485 | 50.3 | 4,263 | |
| | 59 | 53 | 45 | 53.7 | 7,236 | 41.7 | 5,619 | Almost recovered. |
| | 76 | 70 | 62 | 50.3 | 6,363 | 43.3 | 5,477 | Recovered with residual paralysis. |
| 24 | 1 | | | 65.0 | 19,565 | 30.3 | 10,033 | |
| | 6 | 5 | | 41.7 | 17,889 | 56.7 | 24,324 | |
| | 17 | 16 | 4 | 20.0 | 6,625 | 79.7 | 26,401 | Prostrate 3 days. |
| | 29 | 28 | 16 | 20.0 | 7,340 | 76.3 | 29,528 | |
| | 173 | 172 | 160 | 57.7 | 15,593 | 34.7 | 9,378 | Recovered with residual paralysis. |
| 25 | 1 | 30 | 16 | 29.3 | 3,289 | 69.3 | 7,779 | Prostrate. |
| | 2 | 31 | 17 | 53.7 | 7,357 | 44.3 | 6,069 | |
| | 10 | 39 | 25 | 56.7 | 8,661 | 39.0 | 5,957 | |
| | 15 | 44 | 30 | 67.0 | 12,462 | 30.3 | 5,636 | |
| | 22 | 51 | 37 | 41.7 | 9,570 | 54.0 | 12,393 | Partial recovery with residual paralysis. |

*Series VI.*—In Table VI are given blood counts made on monkeys which had completely recovered from acute poliomyelitis and proved immune to subsequent inoculations of active virus. All the animals




TEXT-FIG. 5, *a* and *b*. (*a*) Lymphocyte curve of Monkey 22 (Table V). (*b*) Lymphocyte curve of Monkey 23 (Table V).

had some residual contractures. Recovery, in the animals of this group, was of long duration, varying from 1 to 3 months at the time of the first blood count.




TEXT-FIG. 6, *a* and *b*. (*a*) Lymphocyte curve of Monkey 24 (Table V). (*b*) Lymphocyte curve of Monkey 25 (Table V).

TABLE VI.

*Blood Counts on Monkeys Which Had Recovered from Acute Symptoms before the First Count.*

| Monkey No. | Day of observation. | Length of time since recovery. | Total lymphocytes. | | Total polymorphonuclear neutrophilic leucocytes. | |
|---|---|---|---|---|---|---|
| | | *days* | *per cent* | | *per cent* | |
| 26 | 1 | 72 | 52.7 | 8,550 | 43.7 | 7,090 |
| | 2 | 73 | 36.3 | 6,561 | 61.3 | 11,080 |
| | 5 | 76 | 55.0 | 6,463 | 40.3 | 4,735 |
| 27 | 1 | 72 | 57.7 | 7,746 | 28.0 | 3,759 |
| | 2 | 73 | 66.7 | 7,270 | 26.3 | 2,967 |
| | 5 | 76 | 72.0 | 7,200 | 20.0 | 2,000 |
| 28 | 1 | 92 | 50.7 | 4,700 | 45.7 | 4,277 |
| | 2 | 93 | 38.0 | 17,733 | 59.7 | 12,149 |
| | 5 | 96 | 43.3 | 6,712 | 54.0 | 8,370 |
| 29 | 1 | 84 | 46.3 | 7,281 | 47.3 | 7,438 |
| | 2 | 85 | 43.3 | 5,932 | 53.7 | 7,357 |
| | 6 | 89 | 40.3 | 8,181 | 52.3 | 10,617 |
| | 8 | 91 | 44.0 | 8,965 | 51.3 | 10,452 |
| | 9 | 92 | 52.7 | 7,879 | 42.7 | 6,384 |
| | 16 | 99 | 33.7 | 7,515 | 61.3 | 13,670 |
| | 20 | 103 | 42.3 | 8,238 | 50.3 | 9,796 |
| | 35 | 118 | 43.3 | 8,335 | 52.3 | 10,068 |
| 30 | 1 | 31 | 73.0 | 16,608 | 21.7 | 4,937 |
| | 2 | 32 | 67.0 | 10,318 | 29.0 | 4,466 |
| | 5 | 35 | 71.7 | 16,168 | 16.7 | 3,766 |
| | 16 | 46 | 39.0 | 14,182 | 60.3 | 20,381 |
| | 20 | 50 | 79.3 | 24,524 | 16.3 | 5,040 |

## DISCUSSION.

All the blood counts made on monkeys during the course of typical acute experimental poliomyelitis show a variation from the normal. This change is apparent in Table VII,[8] in which the average lymphocytes and polymorphonuclear counts and percentage during the acute stage are compared with normal averages. There are included aver-

[8] Counts on Monkey 6 (Table III) are not included in the computation.

ages at the time of the highest and also of the lowest lymphocyte count. The variations are sufficiently great to warrant definite conclusions.

After injection of active poliomyelitic virus the lymphocytes are diminished but return to their former number and are actually increased between the 4th and 6th days of the incubation period (Table III). The polymorphonuclear count is high at this time. The normal average of lymphocytes of 11,815 (Table I) is increased to an average of 19,696 though the average percentage is slightly lowered. During the first 3 days after onset a marked diminution in the lymphocytes takes place. Thus, instead of an average normal lymphocytic count of 11,815, the number is 3,302, and the average percentage

TABLE VII.

*Average Variation in White Cells during Infection with Poliomyelitis.*

| Status of monkeys at time of counts. | No. of animals studied. | Total No. of counts. | Large and small lympho-cytes. Aver-age. | Average total No. of lympho-cytes per c.mm. | Average total No. of polymorphonu-clear neutrophilic leucocytes. | |
|---|---|---|---|---|---|---|
| | | | *per cent* | | *per cent* | |
| Normal | 40 | 121 | 53.7 | 11,815 | 41.1 | 9,116 |
| Incubation period at time of highest lymphocytic count | 12 | 12 | 44.0 | 19,696 | 54.3 | 13,383 |
| In acute stage at time of lowest lympho-cytic count | 12 | 12 | 15.6 | 3,302 | 83.7 | 18,231 |
| Prostrate | 4 | 6 | 21.9 | 2,758 | 76.5 | 10,800 |
| Recovered with residual paralysis | 6 | 22 | 53.2 | 9,026 | 41.3 | 6,800 |

is 15.6. At this time the polymorphonuclear neutrophilic leucocytes are materially increased in number (18,231) as compared with an average normal of 9,116, and the percentage is also increased from an average of 41 to 84 per cent of the total white cells When the monkeys become completely prostrate metabolism is at low ebb, and there occurs a further decrease in the actual number of lymphocytes (Table III) which remains low for long periods (Tables II and V). The total number of polymorphonuclear neutrophilic leucocytes returns to normal, but there remains a relative increase averaging 77 per cent. Finally, during recovery both types of cells return to the average normal count and relation. No stimulation of the lympho-

cytes above normal appears during recovery. The counts made on one animal (Monkey 24, Table V) at 160 days after onset are almost the same as those made before the injection of virus.

In the monkeys receiving virus but not developing symptoms there seemed to be a constant tendency for the lymphocytes to decrease following the administration of the virus (Table IV). This decrease was followed by a gradual return to normal.

Monkey 23 (Table V) was x-rayed before inoculation with the virus of poliomyelitis, and the return of the circulating lymphocytes to their normal level, in this animal, seemed to be considerably delayed. As the x-rays have a depleting effect on the circulating lymphocytes[9] similar to that exhibited by the virus of poliomyelitis, the protracted recovery may, in this instance, depend on a summative action of the two agents.

Monkey 22 (Table V) was also included in the series used by Smillie[6] in attempts to produce poliomyelitis with cultivated virus. Typical pathological lesions were not observed at autopsy; however, the symptoms and the blood curve simulating those observed in known poliomyelitic monkeys are suggestive and offer possible additional proof that the monkey developed mild poliomyelitis after intracerebral inoculation with the fourth generation of a culture of the globoid bodies and recovered before it was etherized for autopsy.

## SUMMARY AND CONCLUSIONS.

Blood counts were made on six series of monkeys before and at various intervals after the injection of active poliomyelitic virus. From the data thus obtained the variations in the circulating white cells have been followed in the several stages of the disease (*a*) before injection, (*b*) during the incubation period, (*c*) during the acute stage, including the stage of prostration, and (*d*) during recovery. On account of experimental conditions not all the monkeys were observed during the four periods, so that averages of counts in several monkeys are used for comparison.

Averages of 121 counts on 40 normal monkeys are recorded.

[9] Amoss, H. L., Taylor, H. D., and Witherbee, W. D., *J. Exp. Med.*, 1919, xxix, 115.

Immediately following the injection of the virus the relative and actual numbers of lymphocytes are slightly diminished. In many cases the curve continues sharply downward. In others from the 4th to the 6th day there is an actual increase for a brief period to a point somewhat in excess of the original count. With the onset of symptoms a lymphocytic crisis takes place. The curve then continues slightly downward, while the polymorphonuclear neutrophilic leucocytes are relatively and actually increased at approximately the same time. During the stage of prostration the curve of the polymorphonuclear neutrophilic leucocytes returns to almost normal, while the lymphocytic curve continues slightly downward. With recovery the lymphocytes slowly return to normal after several weeks. There is no evidence of lymphocytic stimulation after recovery.

Eosinophilic, basophilic, large mononuclear, and transitional leucocytes follow the depressions and stimulations exhibited by the neutrophilic cells of the same series.

The results here recorded are consistent with the observations of Peabody, Draper, and Dochez on human cases.

The increase in the total number of circulating lymphocytes after the lymphocytic crisis is coincident with the passing of the acute stage.

Additional evidence is presented to indicate that Smillie produced atypical but definite poliomyelitis in the monkey with cultivated virus.