STUDIES ON EXPERIMENTAL PNEUMONIA.

VI. ACTIVE IMMUNITY FOLLOWING EXPERIMENTAL PNEUMOCOCCUS PNEUMONIA IN MONKEYS.

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The tendency of certain individuals to repeated attacks of pneumonia has at times given rise to doubt whether acquired immunity to pneumonia exists. Considerable evidence, however, can be brought forward to show that a rather high degree of immunity to the pneumococcus follows an attack of pneumonia. The crisis itself is a striking expression of immunity. Furthermore, Dochez has shown that the serum of patients convalescing from pneumonia usually contains protective substances against the homologous type of pneumococcus, and Blake has demonstrated precipitins in the serum of cases of pneumonia that terminate favorably. Aside from these clinical studies, however, accurate information on the subject of immunity following pneumonia is meager.

The experiments herewith reported were performed for the purpose of testing the degree of active immunity in monkeys subsequent to an attack of experimental pneumococcus pneumonia.

Usually the monkey has first been subjected to a pneumonia of one of the four pneumococcus types; and following this, the resistance to reinfection with a pneumococcus of the same type has been tested. Then, as in the study of vaccination with living pneumococci (Paper V), tests for cross-immunity against one or more of the other types of pneumococcus have been carried out. The same virulent pneumococci were used in these experiments as in the previous studies and the technique used for producing experimental pneumonia was identical with that already described. Philippine monkeys (Macacus syrichtus) were employed throughout.

Active Immunity Following Experimental Pneumococcus Type I Pneumonia.

The first experiment was a test for active immunity following experimental Pneumococcus Type I pneumonia. It was shown in Paper I that experimental pneumonia in monkeys is usually fatal when a highly virulent pneumococcus is used for producing the disease. By using very minute infecting doses, however, a certain number of recoveries can be obtained. In a series of Macacus monkeys inoculated intratracheally with a virulent Pneumococcus Type I, two recovered. The following experiment gives the record of these two monkeys.

**Experiment 1.—**Apr. 29, 1919. Monkey 75 received 0.0001 cc. and Monkey 77, 0.000001 cc. of broth culture of Pneumococcus Type I intratracheally. Both monkeys promptly developed symptoms and signs of lobar pneumonia, with positive blood cultures and sharp leucocyte reactions (Table I, Text-fig. 1). Both monkeys made uneventful recoveries.

2 weeks after the recovery of Monkeys 75 and 77, their blood was tested for agglutinins and protective bodies. Monkey 77 exhibited no agglutinins, but did show some protective bodies; the mouse that received 0.0000001 cc. of culture lived 4 days, and the mouse receiving 0.000001 cc. lived 3 days.

**TABLE I.**

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<tr>
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<tbody>
<tr>
<td>75</td>
<td>4,200</td>
<td>0.0001 Shadow, R. L., L. L.*</td>
<td></td>
<td>Clinical pneumonia. Recovery by crisis on 12th day.</td>
</tr>
<tr>
<td>77</td>
<td>2,600</td>
<td>0.000001 Shadow, L. L.</td>
<td></td>
<td>Clinical pneumonia. Recovery by lysis on 11th day.</td>
</tr>
</tbody>
</table>

* R. L., R. M., R. U., etc., indicate lobes of the lung. The cardiac lobe is included as part of the right lower lobe.

Text-Fig. 1, a and b. Experimental Pneumococcus Type I pneumonia. (a) Monkey 75; (b) Monkey 77.
### TABLE II.

**Active Immunity Following Experimental Lobar Pneumonia.**

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<tbody>
<tr>
<td></td>
<td></td>
<td>Control.</td>
<td>Broth culture of Pn. 1 intratracheally.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>cc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>4,200</td>
<td>0</td>
<td>0.001</td>
<td>Remained well. No signs of pneumonia.</td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>2,600</td>
<td>0</td>
<td>0.000001 cc. D. 48 hrs.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>0.00001 cc. D. 48 hrs.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>0.000001 cc. D. 4 days.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0000001 cc. D. 4 days.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>109</td>
<td>4,585</td>
<td>0</td>
<td>0.001</td>
<td>Clinical pneumonia. D. 5th day.</td>
<td></td>
</tr>
<tr>
<td>(control).</td>
<td></td>
<td></td>
<td></td>
<td>Lobar pneumonia; stage of engorgement, R. U., L. U., R. M., L. M.</td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>2,710</td>
<td>0</td>
<td>0.00001</td>
<td>Clinical pneumonia. D. 7th day.</td>
<td></td>
</tr>
<tr>
<td>(control).</td>
<td></td>
<td></td>
<td></td>
<td>Lobar pneumonia; mixed red and gray stages, entire right lung; acute pericarditis.</td>
<td></td>
</tr>
</tbody>
</table>

* D. indicates died; S., survived.
The next step was to test these two monkeys for active immunity against Pneumococcus Type I.

Experiment 2.—May 27, 1919. Nearly 3 weeks after their recovery from pneumonia, Monkeys 75 and 77, with two Macacus controls were injected intratracheally with a broth culture of virulent Pneumococcus Type I (the same

strain with which they had been previously infected). Monkey 75 and its control, Monkey 109, each received 0.001 cc. of culture; Monkey 77 and its control, Monkey 110, each received 0.000001 cc. Table II and Text-figs. 2 and 3 show the results obtained.

Text-Fig. 2, a and b. Active immunity against Pneumococcus Type I following Pneumococcus Type I pneumonia. (a) Monkey 75; immunity following pneumonia. (b) Monkey 109; control.
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Pneumococci per 0.5 cc of blood

Date: 26, 27, 28, 29, 30, 31, 1, 2

Active immunity against Pneumococcus Type I; (a) Monkey 71; immunity following pneumonia. (b) Monkey 10; control.

Temperature
In Table II it will be seen that the two monkeys which had had a previous attack of Pneumococcus Type I pneumonia remained well, while the two controls developed Pneumococcus Type I pneumonia. Monkey 75 (Text-fig. 2) showed a very slight temporary rise in temperature and leucocytes, but was lively and well and displayed no symptoms whatever of pneumonia. The rather high average temperature was attributed at the time to the hot weather, but subsequently autopsy showed a chronic pulmonary tuberculosis. Monkey 109, the control to Monkey 75, was overwhelmed by the large dose (0.001 cc.) of culture injected and died on the 3rd day of the illness with lobar pneumonia and Pneumococcus Type I septicemia.

Monkey 77 (Text-fig. 3) also remained well and showed very little temperature or leucocyte reaction. The control, Monkey 110, developed lobar pneumonia and died on the 7th day of the disease with a heavy Pneumococcus Type I septicemia.

These experiments corroborate the evidence already at hand in favor of a high degree of active immunity following pneumococcus pneumonia. It will be noted that this immunity existed in Monkey 75 without any evidence of agglutinins or protective substances in the blood. The amount of protective substance in Monkey 77 was almost negligible, yet it also was able to resist reinfection.

Tests for Cross-Immunity Following Pneumococcus Type I Pneumonia.

In the preceding paper it has been shown that vaccination with a living culture of Pneumococcus Type I conferred a high degree of immunity against pneumonia of the homologous type; and furthermore, that by such vaccination a certain but variable amount of cross-immunity was also established against the other types of pneumococcus pneumonia. It was therefore desirable to determine whether a similar cross-immunity could be demonstrated in monkeys that had survived an attack of Pneumococcus Type I pneumonia.

Test for Cross-Immunity against Pneumococcus Type II Following Pneumococcus Type I Pneumonia.—In the following experiment one of the monkeys (No. 75) that resisted reinfection with Pneumococcus Type I was tested for cross-immunity against Pneumococcus Type II. The same virulent strain of Pneumococcus Type II was
### TABLE III.

**Pneumococcus Type II Pneumonia Following Pneumococcus Type I Pneumonia.**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>3,862</td>
<td>Pn. I pneumonia.</td>
<td>Resisted reinfection with Pn. I.</td>
<td>0 0.000001 cc.</td>
<td>D. 60 hrs.</td>
<td>0.000001 cc.</td>
<td>0.1</td>
<td>Clinical pneumonia. Crisis on 8th day. Continuous temperature. Killed on 22nd day.</td>
</tr>
<tr>
<td>91 (control)</td>
<td>4,002</td>
<td></td>
<td></td>
<td>0.0001 cc.</td>
<td>D. 18 hrs.</td>
<td>0.0001 cc.</td>
<td>D. 18 hrs.</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Pneumococci Per 0.5cc of Blood

Fig. 4. Monkey 25. Pneumococcus Type II pneumonia subsequent to Pneumococcus Type I pneumonia. Pneumococcus Type I pneumonia from Apr. 29 to May 10.
Text-Fig. 5. Monkey 94; control for Monkey 75. Experimental Pneumococcus Type II pneumonia.
used in this experiment that had been employed in the vaccination experiments.

Experiment 3.—June 24, 1919. 6 weeks after the attack of Pneumococcus Type I pneumonia, Monkey 75 received 0.1 cc. of broth culture of Pneumococcus Type II intratracheally. Monkey 91 served as control, and received the same dose of culture. The results are shown in Table III and Text-figs. 4 and 5.

Both monkeys developed pneumonia and ran rather unusually long courses with final recovery. Monkey 75, however, continued to run a slight temperature and was killed July 15, the 22nd day after inoculation. Autopsy showed a chronic pulmonary tuberculosis, with early miliary tuberculosis of the various organs. Monkey 91, the control, had had an attack of spontaneous Pneumococcus Type IV pneumonia several months before the experiment, so was not an ideal control. It was the only one available, however, at this time, and had to be used. Ordinarily, an infecting dose as large as the one used in this experiment (0.1 cc.) would have been sufficient to kill a control.

The experiment shows that an attack of Pneumococcus Type I pneumonia did not afford enough cross-immunity to protect Monkey 75 from infection with Pneumococcus Type II. How much of a factor the tuberculosis was in this animal and to what extent it affected the immunity it is impossible to say. The tuberculous process was probably active at the time the immunity against Pneumococcus Type I was tested, for the animal was then running an abnormally high temperature; yet the presence of tuberculosis apparently did not lessen the degree of resistance to Pneumococcus Type I.

Tests for Cross-Immunity against Pneumococcus Type III Following Pneumococcus Type I Pneumonia.—The next step in this series of experiments was to test a monkey that had recovered from Pneumococcus Type I pneumonia for cross-immunity against Pneumococcus Type III. Monkey 77 was selected for this test.

Experiment 4.—June 24, 1919. 6 weeks after recovery from Pneumococcus Type I pneumonia, Monkey 77 received 0.1 cc. of broth culture of virulent Pneumococcus Type III intratracheally. The control, Monkey 115, received the same dose at the same time. Table IV and Text-fig. 6 show the results obtained.
TABLE IV.
Inoculation with Pneumococcus Type III Following Pneumococcus Type I Pneumonia.

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<thead>
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<tbody>
<tr>
<td>77</td>
<td>2,680</td>
<td>Experimental Pn. I pneumonia.</td>
<td>Resisted reinfection with Pn. I.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>115 (control)</td>
<td>3,015</td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
</tr>
</tbody>
</table>

Text-FIG. 6, a and b. Inoculation with Pneumococcus Type III following Pneumococcus Type I pneumonia. (a) Monkey 77; Pneumococcus Type I pneumonia from Apr. 29 to May 9. (b) Monkey 115; control.
Monkey 77 remained well and had no symptoms whatever except a moderate rise in leucocytes. The temperature of the control monkey rose to 103.4°F. and there was a sharp leucocyte reaction, but the blood culture remained sterile and the monkey did not appear very sick. Evidently the control suffered nothing more than a bronchitis or a very small patch of consolidation.

The Pneumococcus Type III strain used in this experiment at no time proved highly virulent for monkeys, though 0.000001 cc. of a broth culture would invariably kill a mouse. It seemed advisable to repeat this test on another monkey using a larger infecting dose of Pneumococcus Type III. Accordingly, another monkey (No. 96) that had recovered from Pneumococcus Type I pneumonia was tested against Pneumococcus Type III. Monkey 96 had Pneumococcus Type I pneumonia from May 13 to 20.4

Experiment 5.—July 1, 1919. Monkey 96, about 6 weeks after the attack of Pneumococcus Type I pneumonia, received 1 cc. of broth culture of Pneumococcus Type III intratracheally (Table V, Text-fig. 7). The control, Monkey 107, likewise received 1 cc. of the same culture intratracheally.

By referring to Table V it will be seen that both monkeys developed a mild interstitial pneumonia, the symptoms of which persisted only 48 hours. Neither monkey presented a positive blood culture at any time. The temperature and leucocyte curves for the two monkeys were strikingly alike.

It cannot be maintained that the vaccinated monkey in this experiment showed any definite cross-immunity against Pneumococcus Type III. The disease ran a mild course in both animals for the probable reason that this particular strain of Pneumococcus Type III though virulent for mice possessed only slight virulence for monkeys.

### TABLE V.

**Pneumococcus Type III Pneumonia Following Pneumococcus Type I Pneumonia.**

<table>
<thead>
<tr>
<th>Monkey No.</th>
<th>Weight</th>
<th>May 12, Broth culture of Pn. I intratracheally</th>
<th>Result</th>
<th>July 1, Broth culture of Pn. III intratracheally</th>
<th>Result</th>
<th>Autopsy</th>
<th>Autopsy cultures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gm.</td>
<td>cc.</td>
<td>cc.</td>
<td></td>
<td>cc.</td>
<td></td>
<td>Lung.</td>
</tr>
<tr>
<td>107 (control)</td>
<td>2,334</td>
<td></td>
<td>1</td>
<td>Very mild pneumonia. Killed on 5th day.</td>
<td>Interstitial pneumonia, R. L.</td>
<td>“ ”</td>
<td>“ ”</td>
</tr>
</tbody>
</table>

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Text-Fig. 7, a and b. Pneumococcus Type III pneumonia subsequent to Pneumococcus Type I pneumonia. (a) Monkey 96; Pneumococcus Type I pneumonia from May 13 to 20. (b) Monkey 107; control.

Tests for Cross-Immunity against Pneumococcus Type IV Following Pneumococcus Type I Pneumonia.—It has been shown in the previous paper that vaccination with a living Pneumococcus Type I gave no appreciable cross-protection against Pneumococcus Type IV pneumonia. In the present study a somewhat similar test was made for cross-immunity against Pneumococcus Type IV following Pneumococcus Type I pneumonia.

Experiment 6.—July 1, 1919. Monkey 77, 7 weeks after the attack of Pneumococcus Type I pneumonia, and the control, Monkey 115, each received 0.1
Text-Fig. 8, a and b. Pneumococcus Type IV pneumonia subsequent to Pneumococcus Type I pneumonia. (a) Monkey 77; Pneumococcus Type I pneumonia from Apr. 29 to May 9. (b) Monkey 115; control.
cc. of Pneumococcus Type IV intratracheally (Table VI). This was a virulent pneumococcus isolated from a case of spontaneous lobar pneumonia (Monkey 97) and killed a mouse in doses of 0.000001 cc. of broth culture.

Both monkeys proved susceptible and ran typical courses of lobar pneumonia (Text-fig. 8). Monkey 77 recovered by crisis on the 7th day, Monkey 115 on the 9th day. Both animals had very pronounced leucocyte reactions and positive blood cultures.

These two cases were about equally severe. As both recovered, it is impossible to say whether Monkey 77 had any cross-immunity or not, but the evidence is against such a hypothesis.

### TABLE VI.

*Inoculation with Pneumococcus Type IV of the Two Monkeys Tested in Experiment 4.*

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<tbody>
<tr>
<td></td>
<td>Protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>0</td>
<td>0.1</td>
<td>Clinical pneumonia. Recovery by crisis on 7th day.</td>
</tr>
<tr>
<td>115</td>
<td>0</td>
<td>0.1</td>
<td>Clinical pneumonia. Recovery by crisis on 9th day.</td>
</tr>
</tbody>
</table>

*Active Immunity Following an Attack of Pneumococcus Type IV Pneumonia.*

The so called Pneumococcus Type IV is not a type in the true sense as it consists merely of a large number of pneumococcus strains which do not fall into the three fixed groups and which usually have no biological connection with one another. An animal immunized against one strain of Pneumococcus Type IV develops agglutinins and protective bodies for that particular strain, but as a general rule this serum fails to agglutinate or protect against other Type IV strains.

The question therefore naturally arose whether an attack of Pneumococcus Type IV pneumonia would confer immunity against a second attack by the same strain, and also whether an attack of
Pneumococcus Type IV pneumonia would confer any cross-immunity against other strains of Pneumococcus Type IV.

In order to answer these questions two monkeys that had survived attacks of Pneumococcus Type IV pneumonia were inoculated a second time with Pneumococcus Type IV as shown in the following experiment.

Experiment 7.—July 1, 1919. A large Macacus, Monkey 19, 3 weeks after an attack of spontaneous Pneumococcus Type IV pneumonia, was injected intratracheally with 0.1 cc. of broth culture of Pneumococcus Type IV, Strain M 97. At the same time Monkey 111, 3 weeks subsequent to an attack of experimental Pneumococcus Type IV pneumonia (Strain M 97) was also injected intratracheally with 0.1 cc. of broth culture of Pneumococcus Type IV, Strain M 97. Table VII and Text-fig. 9 show the results of this experiment.

Both monkeys developed Pneumococcus Type IV pneumonia and both recovered. Monkey 19 ran a typical mild course with only one positive blood culture. Monkey 111, inoculated a second time with the identical strain injected 1 month previously, developed an abortive pneumonia and was sick only 2 or 3 days. The blood culture in this animal was never positive.

An unexpected sequel to this experiment presented itself when a biological study was made of the various Pneumococcus Type IV strains that had been isolated during the epidemic of spontaneous pneumonia in the stock monkeys. It was found that the strain originally isolated from Monkey 19 during the attack of spontaneous pneumonia and Strain M 97 were agglutinated by the same Pneumococcus Type IV serum; in other words they belonged to the same biological group. The experiment had been planned to test the amount of immunity against Pneumococcus Type IV following an attack of Pneumococcus Type IV pneumonia. Monkey 19 was to be tested for cross-immunity against a supposedly heterologous strain, Monkey 111 for active immunity against the homologous strain. But since the pneumococcus isolated from Monkey 19 during its original attack of spontaneous pneumonia and Strain M 97 belong to the same subgroup of Pneumococcus Type IV, it is apparent that in both monkeys we were testing for active immunity against the homologous strain of Pneumococcus Type IV. Strangely enough both monkeys failed to show sufficient immunity to protect them against reinfection with
## TABLE VII.

*Reinfection with Pneumococcus Type IV Following an Attack of Pneumococcus Type IV Pneumonia.*

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</thead>
<tbody>
<tr>
<td>19</td>
<td>4,000</td>
<td>June 1-8. Spontaneous (Strain M 19).</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
<td>Clinical pneumonia. Recovery by crisis on 7th day.</td>
<td>Lung.</td>
</tr>
<tr>
<td>111</td>
<td>1,670</td>
<td>May 27-June 9. Experimental (Strain M 97).</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
<td>Temporary febrile reaction and leucocytosis. Killed on 5th day.</td>
<td>Heart's blood.</td>
</tr>
</tbody>
</table>
**TEXT-FIG. 9, a and b.** Pneumococcus Type IV pneumonia subsequent to Pneumococcus Type IV pneumonia. (a) Monkey 19; spontaneous Pneumococcus Type IV pneumonia from June 1 to 8. (b) Monkey 111; experimental Pneumococcus Type IV pneumonia (Strain M 97) from May 27 to June 9.
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the same strain of Pneumococcus Type IV which had excited in them an attack of pneumonia a month previously. But although these monkeys were unable to resist reinfection with Pneumococcus Type IV, it is clear that one of them, Monkey 111, had a considerable amount of active immunity—enough to reduce the second attack to a very mild, abortive pneumonia. Furthermore, it is worthy of note that the autopsy on this monkey showed that it had never recovered completely from the first attack. An old unresolved pneumonia was found in the right upper lobe, while the fresh infection was limited to the right lower lobe.

Test for Cross-Immunity against Pneumococcus Type I Following Pneumococcus Type IV Pneumonia.—The last experiment in this series was undertaken to determine whether an attack of Pneumococcus Type IV pneumonia would confer any cross-immunity against Pneumococcus Type I pneumonia.


This experiment is in line with the other experiments on cross-immunity. The monkey was not sufficiently immune to resist infection with Pneumococcus Type I, but, in view of the mild course and the practically sterile blood culture, it would appear that enough cross-immunity was present to modify favorably the course of the disease. Certainly, if an attack of Pneumococcus Type IV pneumonia does not stimulate enough protection to prevent a second infection by the same strain, it could hardly be expected to elaborate an adequate cross-immunity against a highly virulent Pneumococcus Type I.
DISCUSSION.

The experiments which have been reported prove conclusively that in monkeys an attack of Pneumococcus Type I pneumonia protects against a second infection by the homologous type. It would be desirable to know how long this immunity lasts, but circumstances have not as yet afforded an opportunity for settling this point.

An attack of Pneumococcus Type I pneumonia gave little if any cross-protection against Pneumococcus Type II pneumonia. The experiments with Pneumococcus Type III were not altogether satisfactory, as the strain employed was not particularly virulent for
monkeys. In both the Type II and Type III experiments, however, rather large infecting doses were employed, 0.1 cc. of Pneumococcus Type II and 0.1 to 1 cc. of Pneumococcus Type III. As in vaccination with living cultures, a small amount of cross-immunity against the other fixed types of pneumococcus is probably always present for a certain length of time following experimental Pneumococcus Type I pneumonia. As in vaccination with living cultures, however, the degree of cross-immunity depends to some extent on individual variation. The virulence and dose of the invading microorganism are, of course, other factors of great importance. An attack of Pneumococcus Type I pneumonia does not appear to induce any higher degree of cross-immunity than vaccination with a living Pneumococcus Type I affords.

It is impossible to say why Pneumococcus Type IV pneumonia fails to protect the monkey against a second infection by the homologous strain when Pneumococcus Type I confers excellent immunity against reinfection. The highly parasitic character of Pneumococcus Type I may account for this difference. At any rate, these observations offer little hope for a satisfactory prophylactic vaccine against Pneumococcus Type IV pneumonia.

From the information obtained in this study it would appear possible that individuals who suffer from repeated attacks of pneumonia are being reinfected from time to time with Pneumococcus Type IV. Further evidence in favor of such a theory is afforded by the fact that in cases of this kind the disease usually runs a mild course.

Attention is again invited to the inconsistency between tests for protective bodies against the pneumococcus in the serum of monkeys and tests for active immunity against pneumonia in these animals. In this respect the results are in harmony with those reported in Papers IV and V where striking disagreements were sometimes noted in the two methods for testing immunity. In the present study, for example, Monkey 75 showed no agglutinins or protective bodies against Pneumococcus Type I in the blood subsequent to the attack of Pneumococcus Type I pneumonia; yet when reinjected, with Pneumococcus Type I intratracheally, this animal possessed a sufficient degree of active immunity to resist reinfection.

CONCLUSIONS.

1. Experimental Pneumococcus Type I pneumonia in monkeys confers on them an immunity which protects them against subsequent infection with the homologous type of pneumococcus. The duration of this immunity has not been determined.

2. A certain amount of cross-immunity against the other fixed types of pneumococcus pneumonia may or may not be present following experimental Pneumococcus Type I pneumonia. The degree of cross-immunity is difficult to measure and probably varies widely with the individual monkey.

3. Experimental Pneumococcus Type IV pneumonia in monkeys confers slight if any protection against subsequent infection with the same, or with an homologous strain of Pneumococcus Type IV.

4. There is no evidence in monkeys of cross-immunity against Pneumococcus Type IV pneumonia following Pneumococcus Type I pneumonia; and conversely, Pneumococcus Type IV pneumonia confers no cross-immunity against Pneumococcus Type I pneumonia.