isolated from severe cases. (*a*) Prophylactic administration: Total number of persons in institution, 305; 156 were inoculated and 149 not inoculated. The case incidence in the inoculated was eight in 156; amongst the uninoculated eighteen in 149. The prophylactic vaccination should be done on two, preferably three occasions. It will probably abolish or modify the toxic type of the disease. (*b*) Curative administration: The dosage in all cases was 1 c.cm., containing streptococcus, 5 millions; meningococcus, 2 millions; pneumococcus, 5 millions; *Bacillus influenzæ*, 2 millions; *Micrococcus catarrhalis*, 5 millions. The first injection was given as soon after admission as was possible, and repeated daily till the temperature fell to normal. In cases with higher temperatures than 103·5° F. *polyvalent antistreptococcus serum* was given subcutaneously (dose 20 c.cm.) as soon as possible, followed by daily dose of 10 c.cm. for three or four days.

Vaccine treatment exercised a distinctly beneficial effect on the symptoms, and cases cleared up rapidly under it. Serum therapy is efficacious if the injections are made before the sixth day, but not if made later.

The conclusion derived from a study of the foregoing results is that the malady under consideration is a "compound" not a simple disease.

Major T. R. Little, C.A.M.C., M.B.

The dominant feature in the post-mortem examination of seventy-three cases of pneumonia supervening on influenza was that of a lobular or bronchial pneumonia. The mucous membrane of the trachea and bronchi was swollen and congested, and covered with a sero-muco-sanguineous exudate. The lungs showed patchy areas of consolidation, varying in size from that of a chestnut to a hen's egg. In most cases there was semi-consolidation of one or more lobes that might well be called a pseudo-lobar type of pneumonia. On section these areas projected somewhat above the general surface. They were from dark red to light red, and in places bordering on a grey colour. This was chiefly marked about the larger and smaller bronchi. On pressure of the cut surface a sero-muco-sanguineous exudate could be forced out of the lumina of the larger bronchi. Sixty per cent. showed a sero-fibrinous pleurisy. The heart was softer than normal, the right side being engorged. A few showed early pericarditis. The other viscera were somewhat congested, but exhibited no obvious

morbid changes. Fourteen per cent. showed active tuberculosis in the lung or bronchial lymph nodes. Thirty-one per cent. showed old pleuritic adhesions. Seventeen per cent. showed interstitial emphysema. Seven cases showed recent rupture of the rectus abdominis.

Microscopical preparations were made in a fair number of cases. Sections of lung were taken from consolidated areas. The quantity of exudate in the air vesicles contained little cellular débris. The vesicles were chiefly filled up with coarse fibrin, serum, exfoliated epithelial cells, a few leucocytes and red blood cells. The lining cells of the vesicles were vacuolated. The capillaries were congested, the walls of the smaller bronchi thickened and merged with the surrounding vesicles, which showed a much greater proliferation of the leucocytes. The lumina of the larger and smaller bronchi contained large numbers of exfoliated epithelial cells intermixed with leucocytes and red blood cells. Sections of the trachea and bronchi showed almost a complete loss of the epithelial surface, with a marked infiltration of leucocytes into the submucous coat. Sections of the bronchial lymph nodes showed a marked absence of the framework with the lymphoid cells widely separated and intermixed with polymorphonuclear and endothelial leucocytes. In sections of the kidney the tubular epithelium was stained poorly, and Bowman's capsules were widely separated from the glomeruli. Sections of the spleen, liver and other organs showed a fair amount of congestion, but were otherwise normal. Sections of the heart wall showed the muscle fibre somewhat separated, but were otherwise normal.

For the bacteriological examination I began with direct smears and cultures. The direct smears proved of little interest. Those examined from exudates of the trachea and bronchi were generally so overloaded with all kinds of bacteria as to make them almost impossible to differentiate. Those made from heart blood and splenic pulp in the great majority of cases showed no bacteria at all. I therefore confined my work to the examination of cultures. These were made from the cut surface of the lung, heart blood and small blocks of splenic pulp. The culture media used for the primary culture were neutral bouillon containing a little human blood and neutral agar containing 5 c.c. human blood per 100, on Petri dishes. Subcultures were made from blood bouillon to blood agar containing 5 c.c. of a suspension of dead staphylococci per 100 of media. I found that this medium stimulates the growth of *Bacillus influenzæ* and many other organisms. Trypsinized blood agar was given a trial, but owing to

contamination and the amount of time involved in its preparation, it was discontinued.

The following organisms were found in the seventy-three cultures :—

Growth	Cut surface of lung: In all	Small blocks splenic pulp: In 14	Heart blood: In 27
Small Gram-positive diplococcus	62	9	23
Bacillus influenzæ	48	5	11
Streptococcus in short chains	41	6	15
Streptococcus albus	40	—	5
Streptococcus aureus	9	5	6
Bacillus coli	23	6	11
Pneumococcus	35	6	9
Gram-negative diplococcus	22	—	—

The air-borne organisms are not included. The small Gram-positive diplococcus was found in pure culture from the lung in twenty-nine plates, heart blood eighteen plates, and spleen four plates. All other organisms were found mixed.

The three organisms found to be predominating—viz., small Gram-positive diplococcus, *Bacillus influenzæ* and streptococcus in short chains, were tested for their virulence on rabbits, guinea-pigs and mice. I began first with mixed cultures of the small Gram-positive diplococcus and *Bacillus influenzæ*, thinking that these two were the causative organisms and working together. Plate cultures containing these two were inoculated into the chest cavity of three half-grown rabbits, each receiving 5 minims of a suspension made from one streak of the colonies on a 3-in. Petri dish suspended in 2 c.c. of normal saline solution. All three died seventy-two hours later. Post mortem all showed a fair amount of cloudy fluid in the chest cavity, sero-fibrinous pleurisy and various sized foci of consolidation, dark red in colour, some just visible to the naked eye, others as large as the end of an ordinary lead pencil. One showed an extensive hæmorrhage into the abdominal cavity, the origin appearing to be the right lobe of the liver. Plates made from the pleural fluid showed a pure culture of mall Gram-positive diplococcus. The same experiment was repeated on a second lot of three rabbits, one of which died in thirty hours. Culture showed *Bacillus influenzæ* as well as the small Gram-positive diplococcus. The other two died—one in forty hours, the other in seventy-two hours.

My next animal experiment was to test the virulence of each of these two organisms. They were cultivated in pure culture and suspensions were made similar to the above. Five-minim doses were

given to six rabbits, three receiving the small Gram-positive diplococcus, the other three *Bacillus influenzæ*. Those receiving the small Gram-positive diplococcus all died within seventy-two hours. Post-mortem findings were much the same as in the animals receiving the mixed cultures. Those receiving *Bacillus influenzæ* showed no apparent change. This convinced me that *Bacillus influenzæ* played no part in the infection in animal experiment.

A third lot of four rabbits received 5 minims of a suspension of dead small Gram-positive diplococci, which were killed in the water bath at 58° C. for one hour. Seventy-two hours later they received 5 minims of the living suspension of the same organism. All were living after twelve days' observation. Thinking at the time that the virulence had run out, as this particular culture had been subcultured daily for fourteen days, I repeated this experiment with six other rabbits, half receiving the living and the other half the killed organism. To my surprise, two receiving the living organism died within thirty-six hours, showing a well-marked pleurisy and areas of consolidation in the lungs. The third one lived for ninety hours, post mortem showing the same as the other two, except for one small portion of a lobe showing a grey coloured wedge-shaped consolidation much like a pyæmic infarct. The animals receiving the dead organism were given 5 minims of the living suspension on the third day. All these animals are living.

Other experimental inoculations were tried on six guinea-pigs and six mice. All proved immune in 5-minim doses into the chest cavity, with the exception of one mouse which died in forty-eight hours. The post-mortem showed the chest cavity full of a dirty clay-coloured fluid, and recent pleural adhesions. Cultures made from the pleural fluid showed a small Gram-positive diplococcus and a motile bacillus resembling *Bacillus coli*.

Broth cultures of the small Gram-positive diplococcus were tried on other mice and guinea-pigs in 5-minim doses, which failed to kill. The streptococcus in small chains failed to kill rabbits, mice and guinea-pigs in 5-minim doses. One of the mice died on the eighth day; no morbid change was noticed.

Peritoneal fluid from rabbits dying from inoculation with the small Gram-positive diplococcus was inoculated into the chest cavity of rabbits immunized against this organism, with no apparent effect. Non-immunized rabbits receiving the same dose of the same fluid died in twenty hours. Post-mortem examination showed a fair increase in the peritoneal fluid and the pleura distinctly congested.

Filtrates from heart's blood, spleen, lung and sputum were also tested out. The filter used was a Berkefeld. Rabbits were given the filtrates in various doses. Six half-grown rabbits were used, all receiving from 1·5 to 4 c.c. into the belly cavity. Observation showed very little change, except for a slight roughening of the fur, and a slight rise in temperature during the first twelve hours. In twenty-four hours the temperature was normal, and all had their usual appetites. One animal, which died after seventy-two hours, showed post mortem an extensive venous congestion of the peritoneum, especially marked on the serous coat of the cæcum, a slight excess of peritoneal fluid and a few tags of fibrin. Cultures made from the peritoneal fluid yielded a pure growth of the small Gram-positive diplococcus. This may be due to the fact that the filters used were new and leakage may have occurred, or too great a pressure may have been used in the filtering.

The agglutination reaction was not very marked. Five bloods were obtained from advanced and convalescent patients. These sera gave a very weak reaction with the small Gram-positive diplococcus, the highest being not above a 1 in 25 dilution, and the lowest a 1 in 10 dilution. The normal serum used as controls would only agglutinate as high as 1 in 10 dilution. Serum from immunized animals reacted in 1 in 20 dilutions. The control normal animal serum gave practically the same results. Three types of the known sera for pneumococcus used in the Rockefeller Institute, New York, were tested. None showed a reaction above a 1 in 10 dilution.

Characteristics of the Small Gram-positive Diplococcus: (*a*) *Morphology.* — Smaller than the pneumococcus on primary cultures. After sub-culture several times it becomes quite pleomorphic—some forms are rounded, some lancet-shaped, some oval, and in liquid medium short chains are formed. A fair number are larger than the pneumococcus.

(*b*) *Staining.*—It stains with all the laboratory aniline colours, but best with dilute aqueous of fuchsin. Gram-stained preparations showed a fair number taking up the counter-stain. Direct smears from exudate showed a halo or capsule.

(*c*) *Biology.*—The best medium for its growth is neutral blood agar or neutral blood broth. Dead staphylococcus added to the medium stimulates the growth. The colonies of the primary culture are very often small "pin-point." When growing with other organisms it is seen along the borders of the streak. Colonies of the cultures transplanted for twenty-five days were as large as a pin-head, widely

separated and semi-transparent. The cultures, if sown too heavily, appear as a semi-transparent film with a slight sagittal border. It grows poorly on ordinary agar, the colonies being just visible to the naked eye. In ordinary bouillon it shows a flocculent growth at the bottom of the tube. It only slightly hæmolyses solid media. Grown in fermentation tubes containing any of the following sugars—galactose, dextrose, lævulose, maltose, saccharose—and a little human blood, no gas is formed and it gives acid reaction. No acid in mannite, or dextrin or glycerine. There is slight coagulation in litmus milk. It exerts reciprocal and exhilarating action on the growth and life of *Bacillus influenzæ*. I have demonstrated this by subculturing these two organisms together as many as twelve times. My experience has been that *Bacillus influenzæ* dies out very quickly after the third or fourth subculture alone.

In conclusion I would say that the small Gram-positive diplococcus proved to be very virulent in animal experiments; it was the predominating organism and must be regarded as of ætiological significance especially in pneumonia supervening on influenza. On account of the large number of cases showing *Bacillus influenzæ* it is probable that the initial infection of the upper air passages is due to *Bacillus influenzæ* and the graver complications due to the small Gram-positive diplococcus superimposed. I look upon the small Gram-positive diplococcus as an intermediate type between the pneumococcus and streptococcus. It differs from both in animal experimental inoculations. It did not agglutinate the three types of pneumococcus serum in a higher dilution than 1 in 10; it was the only organism found in pure culture in cases studied by me. I am satisfied from animal experiments that a vaccine prepared from it proves of prophylactic value.

Captain HALLOWS, R.A.M.C.

In June, 1918, at Aldershot, we dealt with a large number of mild cases. The patients complained of sore throat and pain in the chest, and a few of these developed pleural effusions. In these cases I found what I termed a diplostreptococcus. The most characteristic feature of that organism to me was its pleomorphism. I subcultured it very carefully, and made slides of twelve different colonies; in every instance I found pleomorphism very evident. Next came the more serious type of this influenza epidemic, which started in September, and since then