Lectures on the theory and practice of vaccination / by Robert Cory.

THEORY AND PRACTICE OF VACCINATION

CORY

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VACCINATION.

BY

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1898.

TO THE

MEMORY OF MY DEAR FRIEND

SIR GEORGE BUCHANAN, F.R.S.,

WHOSE EXAMPLE WAS

AS AN ENSIGN TO ALL THAT WAS TRUE AND NOBLE,

BUT AS A DRAG TO THAT WHICH WAS

FALSE AND DISHONOURABLE.

PREFACE.

For the last twenty-two years I have been engaged in the practice and teaching of vaccination. The six chapters contain the substance of the six lectures I periodically deliver to my pupils, together with the incorporation of several papers which I have from time to time published in the periodicals, and now for the first time publish in book form. The whole of the work was written before the final report of the Royal Commission on Vaccination was issued, except a short paragraph on page 3 and the completion of the report of the first case given on page 60. I am not, therefore, indebted to this for any information, and it may be taken, so far as I am concerned, as entirely independent.

ROBERT CORY.

73, Lambeth Palace Road, S.E.,
December, 1897

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ON THE

THEORY AND PRACTICE OF VACCINATION

LECTURE I.

THE REASONS WHICH LED THE LEGISLATURE OF THIS COUNTRY TO IMPOSE THE VACCINATION LAWS UPON THE PEOPLE, AND THE DUTY ENTAILED UPON EVERY MEDICAL MAN TO SUPPORT THOSE LAWS AT THE PRESENT TIME.

A good introduction to the study of vaccination is a consideration of the reasons that led the legislature of this country to impose the vaccination laws upon the people, and the duty entailed on medical men to support those laws at the present time. This consideration is now all the more called for, as we no longer have the horrors of natural small-pox before us; the unthinking are apt to overlook them and thus to magnify the nugatory evils of vaccination, forgetting, or not considering, the saving of life and misery which we derive from it.

Mr. Cross, writing in 1820 of the epidemic of small-pox which visited Norwich in 1819, says in conclusion:

'I advocate vaccination because I believe it to be the most powerful means of preventing the misery attendant on disease, and of saving human life, which Providence has vouchsafed to put into the hands of man; my time has been given up to the gratuitous practice of it, because I can thus do more good amongst the poor than by prescribing pills and potions, and I regard every drop of the vaccine ichor as the most active material that can be admitted into the list of our prophylactic remedies. I am, therefore, grateful to the philosopher who has taught us to wield this weapon of defence in overcoming *the worst of human maladies*.

'The more we reflect upon the professional career of Jenner, the more must he excite our admiration for the scientific investigations by which he established his discovery—the nobleness with which he gave it fully to the public—the temper and ability with which he defended it against opponents often not of the best character. May his life be uniformly happy, and his name immortal!'*

Such was the opinion of Mr. Cross, writing in 1820; and be it remembered that the discovery of vaccination had only been published twenty-two years, and its adoption had not become general, consequently he was writing with most of the horrors of small-pox still before him. He calls small-pox 'the worst of human maladies.' Worst, because it was the most common, and withal the most fatal disease to which the human race was liable; scarring, or not unfrequently blinding, those it did not destroy.

Of those who died in London from all causes, small-pox occasioned death in one-twelfth—that is to say, the average yearly deaths from small-pox would have been 6,577, if the same mortality was occasioned by it at the present time as was occasioned by it in the last century, instead of only 1,227, which is the actual average mortality from small-pox in London for a like period, and that period embraces the great epidemic of 1871. The average yearly deaths from small-pox that occurred between the period of 1867 and 1885, and the annual average of deaths from all causes, have been taken for the above comparison, as it is wished to show, as far as possible, the effects of vaccination alone on small-pox. 1867 was the year of the Amended Vaccination Act, and 1885 was the year when deportation of small-pox first took place from London, and deportation seems to have had a very great influence in diminishing the disease.

The diminution of small-pox must be looked at from at least two sides; that is to say, from the diminished infectibility of the population, which is what vaccination is capable of bringing about, and also from the diminished

* 'A History of the Variolous Epidemic which occurred in Norwich in 1819,' by John Cross.

infectiveness of the disease, which is what deportation is capable of doing.

Mr. Power, the Assistant Medical Officer of the Local Government Board, has shown, in the report of the Board for 1880-81, that small-pox was especially prevalent round about the small-pox hospital at Fulham, and this prevalence could not be attributed to direct personal infection. Something akin to this observation of Mr. Power's had been noticed by Mr. Cross during the Norwich epidemic of small-pox in 1819. For he writes, 'It is certain that the epidemic at its commencement was milder. The first petechial case which I saw was in the latter end of May. The virulence of the contagion seemed to keep pace with the increasing prevalence of the disease, and to be heightened in proportion to the number suffering from it at one time.'*

To Mr. Power, however, we are indebted for having conclusively shown that, from the segregation of cases of small-pox at the Fulham Small-pox Hospital, small-pox was rendered more prevalent in the region of the hospital.

Further evidence on this point may be gathered from, first, the epidemic which took place at Sheffield in 1887-88.† Here there was a hospital for small-pox in a populous neighbourhood, and, as with the epidemic at Gloucester, where similar conditions existed, reported on by Dr. Sidney Coupland, the epidemic of small-pox was severe. On the other hand, at Leicester, where the small-pox hospital is situated *outside registration Leicester*, small-pox is apparently trifling. 'Outside registration Leicester' is mentioned because it is not wished to attach undue weight to the argument. Pains are taken at Leicester to remove as early as possible cases of small-pox to the hospital, and if the patient dies, the case is not registered in Leicester, but in the district where the hospital is situated; hence, Leicester appears freer from small-pox than is actually the case.

* 'A History of the Variolous Epidemic which occurred in Norwich in 1819,' by John Cross, p. 14.

† Report on an Epidemic of Small-pox at Sheffield, 1887-88, by Dr. Barry, of the Local Government Board.

The outcome of Mr. Power's observations was, that cases of small-pox when notified have been sent out of London to ships or hospitals quite away from human habitation. The result has been quite phenomenal; for small-pox deaths, which on the average for the ten previous years to the deportation of small-pox had been 1,121, fell in the succeeding nine years to a yearly average of only 43·4, or $\frac{1}{26}$ of what they had been.

But diminished number of deaths from small-pox is only a part of the good derived from vaccination, for those whom small-pox slays at the present day have attained, on the average, to at least fifteen years' longer life than those who died from it in pre-vaccination times.

Small-pox, before the introduction of vaccination, was really a disease of childhood, as whooping-cough, measles, and scarlet fever are at the present day, and consequently nearly the whole death-rate used to fall upon the children, just as the above-named diseases do at the present time, and individuals did not have small-pox later in life because they had obtained their protection by having had an attack in infancy. That this was the case may be gathered from records of the deaths from small-pox at Warrington, at Chester, at Kilmarnock, at Manchester, and from Geneva. The following table (Table I.) has been drawn up to show the age, as far as possible, at time of death from small-pox at these places in pre-vaccination times. It will be seen that 83·15 per cent. of the deaths from small-pox occurred in children under 5 years of age, and as many as 96·75 occurred in children under 10 years. At the present time the greatest number of deaths from small-pox among those who have been vaccinated in infancy takes place between the ages of 20 to 40, and not in early childhood as in the pre-vaccination times. See A, Table II., p. 6. In Table III., p. 6, the ages in the pre-vaccination times and the present time are contrasted.

This later table shows how greatly the age of death from small-pox has been altered. This, no doubt, is partly due to the present opportunities of being affected by small-pox

TABLE I.

SMALL-POX IN THE PRE-VACCINATION TIMES.

	Year 0-1.	Years 1-5.	Years 5-10.	Years 10-20.	Years 20-40.	Age not stated.	Total.	
Warrington, 1773 ...	49	190	12				251	On the authority of Dr. Gormall, of Warrington. Published in a paper of his, 'A Report of the Epidemic of Small-pox in 1892-93, in the Borough of Warrington,' 1893.
Per cent.	19·52	75·70	4·78					
Chester, 1774* ...	51	129	22				202	On the authority of Dr. Paget, Medical Officer of Health for Salford. Published in the 'Transactions of the Epidemiologic Society' for 1883-84 (new series), vol. iii.
Per cent.	25·25	63·86	10·89					
Kilmarnock, 1728-64	118	468	21	4	11 { 2 / 9		622	On the authority of Dr. McVail, of Kilmarnock, N.B. Published in the supplement containing the report of the Medical Officer of the Local Government Board, 1884.
Per cent.	18·97	75·24	3·38	0·64	1·77			
Manchester, 1768-74	140	419	29	1			589	On the authority of Dr. Percival.
Per cent.	23·77	71·14	4·92	0·17				
Total	358	1206	84	5	11		1664	
Per cent. ...	21·51	72·48	5·05	0·3	0·12			
Geneva, 1580-1760 ...	5467		1058	180	87 { 70 / 17		6792	On the authority of Duvillard, quoted by Sir John Simon in his 'Papers relating to the History and Practice of Vaccination,' p. xxx. Published in 1857.
Per cent.	80·49		15·58	2·65	1·28			
Total	7031		1142	185	98		8456	
Per cent. ...	83·15		13·60	2·19	1·16			

* Interesting as the year in which Benjamin Jesty, a farmer, first vaccinated his wife and son.

Table II.

A.—VACCINATED BEFORE DEPORTATION.

Years.	Age 0-1.	Age 1-5.	Age 5-20.	Age 20-40.	Age 40-60.	Age 60-80.	80 and upwards.	Deaths from all causes.
1882	1	3	21	57	20	5	1	82,905
1883	—	1	7	27	7	—	—	80,578
1884	1	7	38	142	56	6	—	83,050
1885	4	2	35	135	32	9	1	80,000
Total ...	6	13	101	361	115	20	2	326,483
Per cent.	0·97	2·1	16·34	58·41	18·61	3·24	0·32	

Total cases, 618 = 0·19 per cent. to total deaths.

B.—UNVACCINATED BEFORE DEPORTATION.

Years.	Age 0-1.	Age 1-5.	Age 5-20.	Age 20-40.	Age 40-60.	Age 60-80.	80 and upwards.	Deaths from all causes.
1882	22	34	68	49	11	—	—	
1883	12	12	18	10	2	1	—	
1884	60	84	92	60	19	3	1	
1885	66	55	110	74	19	6	—	
Total ...	160	185	288	193	51	10	1	
Per cent.	18·02	20·84	32·43	21·73	5·74	1·13	0·11	

Total cases, 888 = 0·27 per cent. to total deaths.

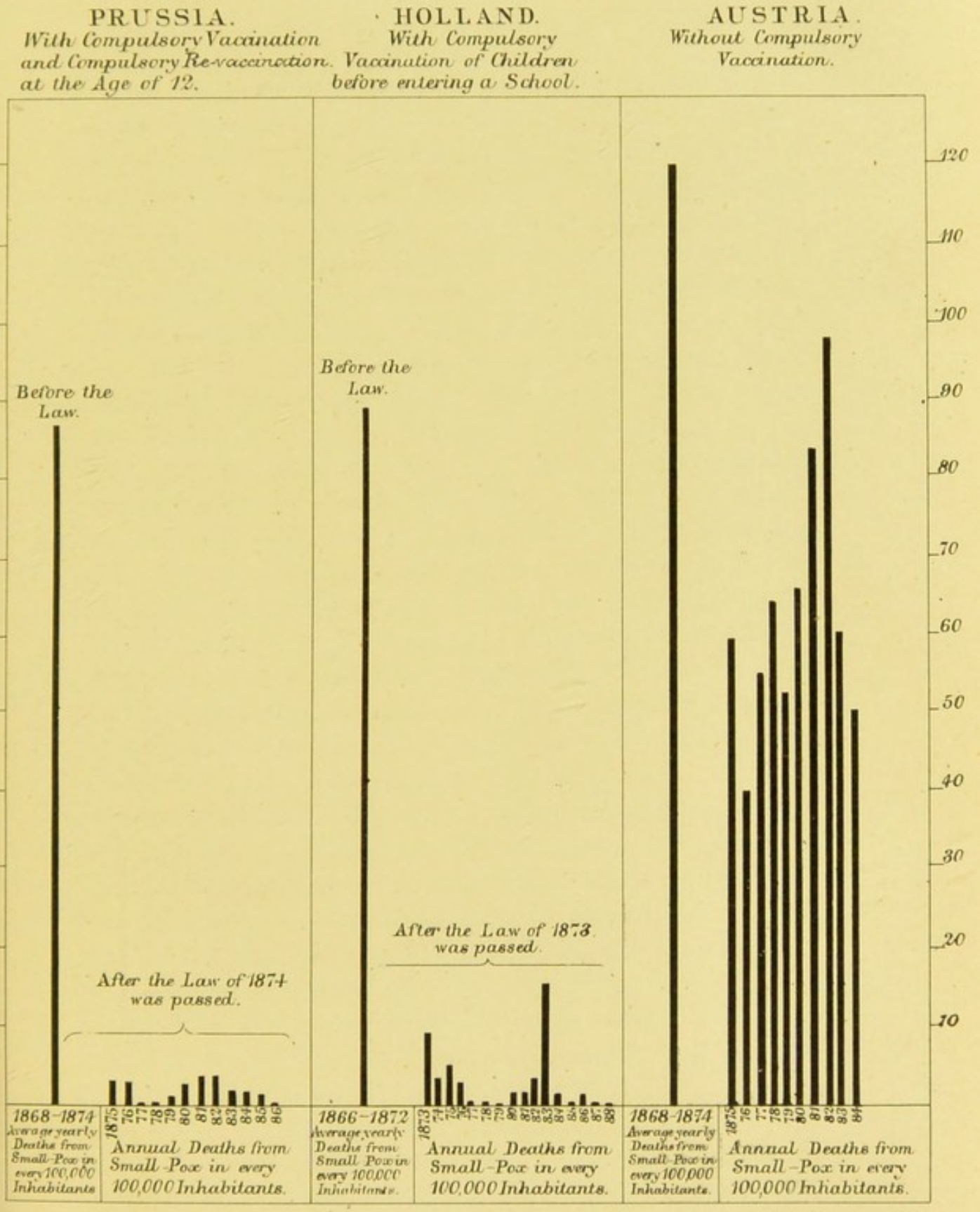
Table III.

	Age 0-5.	Age 5-10.	Age 10-20.	Age 20-40.	Age 40-60.	Age 60-80.	80 and upwards.
Pre-vaccination times -	83·15	15·79	15·79	1·16	0	0	0
Present - - -	3·07	16·34	16·34	58·41	18·61	3·24	·32

being so much less than they were formerly. But it must be mainly due to the evanescent protection which infantile vaccination gives.

The protective power of vaccination is further shown in Table IV., which was drawn up by the late Dr. Carsten, of the Hague. It gives the average deaths from small-pox in Germany before compulsory vaccination at the age of 12 was enforced, and also the annual deaths from small-pox since. The same is also given for Holland as far as possible, for Holland has no direct compulsory law. Every child in

Table IV.



West, Newman lith.

Holland has to be vaccinated before it enters a school, and the law compels every child to be sent to school. The same is given for Austria, where there is no compulsory vaccination of any kind, and here it will be seen how the annual deaths from small-pox remain high. The protective power of vaccination is, moreover, shown by examination of the arms for vaccination scars among those who are pitted with small-pox.

Since November, 1884, I have observed, whenever possible, the scars of vaccination, if such existed, on every person who had become pitted with the small-pox which came before me at St. Thomas's Hospital and at the vaccination stations with which I am connected. These persons have been almost all women; indeed, out of 456 cases in which inspection was permitted, only 19 were among males. Every case examined is given in Table VI., p. 12. In 1888 I had collected 152 cases, which were published in the 'Transactions of the Epidemiological Society' for 1887-88.

In what follows hereafter, Cases 24, 37, 65, 96, 131, 246, 274, and 362 are eliminated from consideration for the following reasons: Cases 24, 37, and 362, because the vaccination took place during the incubatory period of small-pox; Cases 65, 131, and 274, because, although they had some indistinct mottling, it was impossible to conclude with any certainty that this was the result of vaccination; Case 96, because from the history it seemed certain that she had not had her attack of small-pox until eleven years old, although she stated that she had had two attacks, one at two years of age, the other at eleven years of age; and lastly, Case 246 because I was not permitted to examine the arm. There are, therefore, $456-8=448$ cases to be dealt with. Out of these 448 cases there are 210 who were admittedly unvaccinated before their attack of small-pox, or 46·87 per cent.; and these admittedly unvaccinated people had their small-pox at the average age of 6·58 years, as will be seen at the end of Table VII., p. 29. This age is indeed high when compared with the average age individuals were attacked with the disease in the last century. However, there are three circumstances to be borne in mind: Firstly,

the greatly diminished prevalence of small-pox in the present day to that which obtained in the last century. It follows, therefore, that the opportunity to become affected is correspondingly not so great, and this would delay the average age at which unvaccinated individuals contract the disease. Secondly, a large proportion of the unvaccinated individuals die of the disease, and these would in the main be the infants; hence we have a considerable portion of the youngest eliminated by death. And, thirdly, only those who have been obviously pitted with small-pox are dealt with. There are some individuals who, although they have had the disease, yet are not obviously pitted. If these could be added, no doubt the average age would be diminished at which small-pox attacks the unvaccinated. There are, besides the admittedly unvaccinated, as many as 105 individuals who, although they say they have been vaccinated, yet have no scar of vaccination, or 23·44. As a matter of fact, there are as many as 70·31 per cent. among those who are pitted with the small-pox who bear no evidence of vaccination. An opinion can be formed of how many of the latter class may be reckoned among the unvaccinated thus: At Lamb's Conduit Street Vaccination Station, since it was opened in 1882 until March in the present year, 1,774 women have been revaccinated. Of these 82 had no scar of their primary vaccination, and 22 out of the 82 went through their presumed revaccination exactly like a primary vaccination, or 26·83 per cent. On the other hand, out of 1,692 women who bore scars of vaccination, it was found that 47 of them went through their revaccination like a primary vaccination in all respects, or 2·78 per cent. If now this latter percentage be deducted from the 26·83 per cent., we obtain 24·05 per cent. as the number who really had never been vaccinated.

From these data we can calculate that of the 105 cases which have no scar of vaccination, 25·25 should be added to the 210 admittedly unvaccinated; this will give then 235·25 as really the number of unvaccinated among the 448 cases, or 52·51 per cent.

Now, the proportion of the unvaccinated to the vaccinated in London is not more than 5 per cent., yet we have seen that people pitted with small-pox are to the extent of 52·51 per cent. unvaccinated; and if, as some contend, there is no protective power in vaccination against the small-pox, what is the meaning of this? I leave this question to be answered by those who hold the above view. For myself, I am content to believe there is protection afforded by vaccination against small-pox, and adduce this as one out of many proofs that such is the case.

At the end of Table VII., p. 33, it will be seen that the average age of 105 individuals who affirm they have been vaccinated, but have nevertheless no scar of vaccination, is 9·07 years when they are attacked by small-pox, and it has just been seen there is good reason for believing that 25·25 of them have never really been successfully vaccinated; and as the average age at which the admittedly unvaccinated have their small-pox is 6·58, therefore $6{\cdot}58 \times 25{\cdot}25 = 166{\cdot}14$, which is the aggregate age at which we may reasonably suppose they had their small-pox. This deducted from 952·64 years, the aggregate age at which people affirm they have been vaccinated but have no scar, equals 786·5, and this divided by $105 - 25{\cdot}25 = 79{\cdot}75$, *i.e.*, $\frac{786{\cdot}5}{79{\cdot}75} = 9{\cdot}86$. Hence this is the average at which those who may be supposed to have been really vaccinated, but who bear no scar of vaccination, have their small-pox.

From Table VII. it will also be seen that those who bear one scar of vaccination have their small-pox at the average age of 17·77, the earliest age being 2. That those who have two scars of vaccination have their small-pox at the average age of 17·82, the earliest age being 7. That those having three vaccination scars have their small-pox at the average age of 18·02, the earliest age being 9. That those having four vaccination scars have their small-pox at the average age of 18·67, the earliest age being 12; and those having five or more scars have their small-pox at the average age of 19·3, the earliest age being 13.

It will be noticed not only does the average age at the time of having small-pox increase directly as the number of the scars, but also the earliest age at which people become liable to contract small-pox after vaccination also increases in the same way, so that we may conclude that vaccination done in five places gives a longer time of immunity from small-pox than when it is only done in one. It has been stated that Cases 24, 37, 362, were eliminated from consideration, because vaccination was performed during the incubatory period of small-pox. Perhaps the reason why may not be obvious to all, and it will not be thought superfluous if it is more fully stated.

The history of Cases 24 and 37 cannot now be given, but that of 362 will serve as an illustration. The girl, who was twenty-three years of age, had her face scarred in the manner faces are scarred when a person has never been vaccinated; and, moreover, the severity of the attack was further evinced by her having lost an eye through the disease, which she had, as she stated, when she was only fourteen months old, after vaccination. Upon questioning her as to her vaccination, she alleged she was vaccinated before she had small-pox, and on examining her arms six large foveated and well-marked scars of vaccination existed, three on each arm, and arranged in the same pattern as my predecessor Mr. Marson was in the habit of placing his insertions of lymph. From the appearance of the scars I could not doubt but they were done before her attack of small-pox. So much, then, was all that could be gathered from the patient herself; but I ascertained her mother's address, and upon calling, her mother told me that her husband was seized with the small-pox one Wednesday, and she took her children, who had not been vaccinated, to Surrey Chapel on the following Tuesday, and that the child in question was taken ill with small-pox on the following Saturday. This girl was therefore vaccinated on the seventh day of the incubatory period of small-pox. In connection with this, the following cases may be mentioned: Three children were vaccinated at Surrey

Chapel, or, I should say, at Victoria Hall, on May 26, 1881. This turned out to be on the ninth day of the incubatory period of small-pox in two, and the seventh day of the incubatory period in one. All the children had small-pox in its unmodified form, yet all the vaccination places had taken perfectly, and were well formed.

The youngest, aged eight, died of small-pox. The other two were seen again, one on June 15, 1895, and she then bore five scars of vaccination; and one on July 10, 1895. He also bore five scars of vaccination. They were both much pitted with the small-pox.

The history of Case 96, which is also one of the excluded ones, is the following: Mrs. L. S. A——, æt. 22, states that she has had small-pox twice, the first attack at the age of two, the second at the age of eleven years. She said she had been successfully vaccinated in infancy, and, indeed, bore three well-marked and characteristic scars of vaccination. She also said that seven others, her brothers and sisters, all had the disease at the same time, although they had all been vaccinated; that they all recovered, and that not one of them is pitted, and that she herself was not pitted from this attack of small-pox. She states her second attack was at the age of eleven years; that she was sent to the hospital ship *Atlas*, and afterwards to Deptford; that from this attack she was pitted, and had since suffered from disease of the hip-joint in consequence of the attack. If this history were true, we should have to believe that she had an attack of small-pox within two years of a successful vaccination done in three places. That this attack of small-pox did not take place during an epidemic year, but in one in which London was remarkably free from the disease, viz., in 1875. That not only she, but seven of her brothers and sisters, all of whom had been vaccinated likewise, had the complaint; nevertheless all recovered, and not one of them was pitted. That she again suffered from the disease within nine years of her alleged first attack. The whole history is so full of glaring improbabilities that we cannot but feel justified in excluding it from Table VII.

TABLE VI.

No. in series.	No. in Case-book.	Age when at-tacked.	Whether vaccinated with effect before having small-pox.	If vaccinated, number and area of scars, the average diameter of scar represented by a line.	Age of patient at time of obser-vation.	Date of observation.	Year patient had small-pox.	Remarks.	
		Days.							
1	206	3	N.V.	.....	20	Feb. 23, 1889	1869	Sparsely scarred, but area of scar large	3 *b*
2	306	3	N.V.	.....	40	April 15, 1890	1850	Scarred with large, ill-defined marks	3 *b*
3	407	7	N.V.	.....	26	June 15, 1893	1867	Area of pocks large, but not numerous	3 *b*
4	331	14	N.V.	.....	19	Oct. 14, 1890	1870	Not much marked	1
5	164	21	N.V.	.....	38	June, 1888	1850	Badly marked	5
6	254	21	Inf.	0	26	Sept. 24, 1889	1863	A scar or two on face	3 *b*
7	283	28	N.V.	.....	23	Jan., 1890	1866	Pits deep, but not large; sparsely dis-tributed	3 *a*
8	83	35	N.V.	.....	24	July 13, 1887	1863	Not deeply pitted	
9	32	42	N.V.	.....	56	June 27, 1887	1831	Somewhat pitted	
10	49	42	N.V.	.....	21	Mar. 25, 1887	1886	Said to be vaccinated; severely pitted, and eye damaged	
11	165	42	N.V.	.....	41	July 18, 1888	1847	Scarred on face	
12	200	42	N.V.	.....	33	Feb. 6, 1889	1856	Much scarred; confined chiefly to the region about nose	
13	358	42	N.V.	.....	34	Nov. 1891	1857	Sparsely, but pits over a large area	3 *b*
14	256	49	N.V.	.....	30	Sept. 24, 1889	1869	Sparsely, but area of scars large	3 *b*
15	16	61	N.V.	.....	32	June 29, 1885	1853	Eye with serious corneal damage; face scarred	
16	236	61	Inf. with-out effect.	0	22	July 9, 1889	1867	Deeply and acutely pitted; not numer-ous	
17	299	63	N.V.	.....	24	Mar. 4, 1890	1866	Scarred	3 *b*
18	335	90	Inf.	0	28	Oct. 29, 1890	1862	Moderately pitted	3
19	346	90	N.V.	.....	32	Mar. 19, 1891	1859	Much scarred	4
20	227	91	N.V.	.....	23	May 9, 1889	1866	Thickly and sharply, though small pocks	3 *a*
21	328	91	Inf.	0	25	July, 1890	1865	Slightly scarred	2

22	270	92	?	0	23	Oct. 17, 1889	1866	Slightly scarred	2
23	39	106	N.V.	.....	28	Feb. 15, 1887	1859	Much scarred on face	2
*24	122	106	Inf.	8 fov.	23	Oct. 20, 1887	1864	Slightly scarred	
25	201	92	?	0	54	Feb. 7, 1889	1835	Slightly marked	2
26	451	122	N.V.	.....	37	Nov. 27, 1894	1857	Considerably pitted	3
27	454	122	N.V.	.....	30	Jan. 3, 1895	1866	Large area ; not very confluent	3 *b*
28	285	152	Inf.	0	27	Feb. 4, 1890	1863	Large area, but sparse	3 *b*
29	92	182	N.V.	.....	52	Aug. 4, 1887	1835	Slightly marked	
30	129	182	N.V.	.....	36	Nov. 1, 1887	1851	Much pitted	
31	148	182	N.V.	.....	32	May 1, 1888	1859	Not much scarred	
32	232	183	N.V.	.....	25	June 18, 1889	1865	Slightly scarred	2
33	394	183	N.V.	.....	30	Feb. 23, 1893	1860	Irregularly scarred on face, especially about nose	3
34	448	183	N.V.	.....	54	Oct. 30, 1894	1840	Sparsely scarred ; large area	3 *b*
35	12	213	N.V.	.....	28	April 12, 1885	1858	Face pitted	
36	77	213	N.V.	.....	30	July 3, 1887	1857	Pits deep, but not numerous	3 *b*
*37	457	244	8 months.	6 good fov.	23	Jan. 16, 1895	1871	Large area ; not very confluent ; lost eye	
38	62	274	N.V.	.....	35	June 2, 1887	1852	Face scarred	
39	117	274	N.V.	.....	32	Sept. 21, 1887	1856	Pitted	
40	242	275	N.V.	.....	41	July 27, 1889	1848	Scarred on face	
41	48	304	N.V.	.....	39	Mar. 23, 1887	1849	Much pitted	
42	154	304	N.V.	.....	25	May 31, 1888	1862	Sparsely, though deeply scarred	3 *b*
43	459	304	N.V.	.....	62	Feb. 12, 1895	1834	Large area ; not very confluent	3 *b*
44	72	335	N.V.	.....	49	June 23, 1887	1839	Perceptibly scarred	
45	208	335	N.V.	.....	56	Mar. 7, 1889	1834	Scarred	3
		Years.							
46	42	1	N.V.	.....	28	Feb. 18, 1887	1860	Much scarred on face	
47	96	1	?	0	62	Aug. 11, 1887	1826	Deeply scarred	
48	104	1	N.V.	.....	24	Aug. 23, 1887	1864	Face scarred	
49	106	1	Inf.	0	46	Aug. 24, 1887	1842	Face scarred	
50	128	1	N.V.	.....	28	Nov. 16, 1887	1860	Distinctly marked	
51	149	1	Inf.	0	24	May 8, 1888	1865	Deeply scarred	
52	181	1	N.V.	.....	36	Nov. 6, 1888	1853	Considerably scarred	3
53	187	1	N.V.	.....	24	Nov. 20, 1888	1865	Scarred	3
54	230	1	Inf.	0	40	May 16, 1889	1850	Scarred	3

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55	265	1	Inf.	0	39	Oct. 8, 1889	1851	Slightly marked	2
56	272	1	N.V.	.....	51	Oct. 24, 1889	1839	Slightly scarred	4*a*
57	275	1	Inf.	0	29	Nov. 12, 1889	1861	Sparsely, and scarred over small area	3*a*
58	290		Inf.	0	26	Feb. 11, 1890	1865	Sparsely, and scarred over small area	3*a*
59	312	1	Inf.	0	24	May 1, 1890	1867	Slightly pitted	2
60	342	1	N.V.	.....	34	Nov. 25, 1890	1857	Large area and sparsely scarred	3*b*
61	351	1	N.V.	.....	28	July 25, 1891	1864	Pitted	3
62	401	1	N.V	.....	34	April 20, 1893	1860	Heavily pitted	4
63	452	1 16	N.V.	.....	25	Dec. 19, 1894	1894	Large area of scar, chiefly about nose	3*b*
64	120	1 33	N.V.	.....	58	Oct. 6, 1887	1831	Severely pitted	
*65	64	1·5	Inf.	?	22	June 9, 1887	1867	Not recorded	
66	65	1·5	N.V.	.....	29	June 9, 1887	1860	Much scarred	
67	91	1·5	N.V.	.....	38	Aug. 2, 1887	1851	Scarred on face	
68	133	1·5	Inf.	0	36	Dec. 14, 1887	1853	Slightly pitted	
69	429	1·5	Inf.	0	46	Mar. 6, 1894	1847	Considerably scarred	3
70	271	1·83	N.V.	.....	39	Oct. 17, 1889	1852	Scarred	3
71	6	2	Inf.	0	27	Mar. 11, 1887	1859	Face pitted	
72	10	2	N.V.	.....	39	April, 1885	1848	Scarred on face	
73	36	2	N.V.	.....	25	Feb. 9, 1887	1864	Severely pitted	
74	107	2	N.V.	.....	40	Aug. 27, 1887	1849	Much pitted	
75	115	2	N.V.	.....	62	Sept. 13, 1887	1826	Badly pitted	
76	116	2	N.V.	.....	21	Sept. 21, 1887	1868	Badly pitted	
77	124	2	N.V.	.....	49	Nov. 1, 1887	1840	Scarred	
78	143	2	N.V.	.....	65	Feb. 21, 1888	1825	Much marked	
79	158	2	Inf.	0	25	June 26, 1888	1865	Much pitted	4
80	170	2	N.V.	.....	36	Aug. 4, 1888	1854	Large scars, not numerous	3*b*
81	199	2	N.V.	.....	27	Feb. 5, 1889	1864	Considerably pitted	3
82	247	2	N.V.	.....	24	Aug. 13, 1889	1867	Very slightly scarred	1
83	262	2	Inf.	0	42	Oct. 3, 1889	1849	Slightly scarred	2
84	266	2	Inf.	0	23	Oct. 8, 1889	1868	Slightly scarred	2
85	269	2	N.V.	.. ...	50	Oct. 10, 1889	1841	Scarred	3

86	311	2	Inf.	1 fov.	27	Apr.	24, 1890	1865	Lost one eye; slightly pitted	3 *b*
87	314	2	N.V.	.....	40	May	1, 1890	1852	Tolerably numerous; largish area	3 *b*
88	316	2	N.V.	.....	22	May	13, 1890	1870	Large area; tolerably numerous	3 *b*
89	327	2	Inf.	0	29	July	1890	1863	Pitted on face	2
90	376	2	N.V.	.....	55	May	31, 1892	1839	Scarred on face severely	4
91	389	2	Inf.	0	48	Jan.	10, 1893	1847	Sparsely but obviously marked	3 *b*
92	393	2	N.V.	.....	24	Feb.	16, 1893	1871	Scantily pitted on face; small area, but deep	3 *a*
93	399	2	N.V.	.....	17	Mar.	30, 1893	1878	Sparsely pitted, but area large	3 *b*
94	423	2	N.V.	.....	36	Nov.	9, 1893	1859	Pitted on face	3
95	425	2	N.V.	.....	32	Jan.	2, 1894	1864	Pitted on face	3 *b*
*96	458	2	Inf.	3	22	Feb.	5, 1895	1884	Considerably pitted; area large	3
97	63	2·5	N.V.	.....	41	June	8, 1887	1848	Slightly pitted	
98	186	2·5	N.V.	.....	52	Nov.	20, 1888	1839	Scarred	3
99	193	2·5	?	0	26	Jan.	15, 1888	1866	...	3 *b*
100	226	2·5	?	0	25	May	9, 1889	1867	...	
101	444	2·5	N.V.	.....	28	Aug.	23, 1894	1869	...	3 *b*
102	191	2 83	N.V.	.....	24	Dec.	18, 1888	1867	Scarred; large area	3 *b*
103	45	3	N.V.	.....	23	Mar.	10, 1887	1867	Markedly pitted	
104	69	3	N.V.	.....	24	June	14, 1887	1866	Slightly scarred	
105	71	3	N.V.	.....	22	June	23, 1887	1868	Deeply pitted	
106	86	3	N.V.	.....	42	July	1, 1887	1848	Face pitted, but not badly	
107	90	3	N.V.	.....	24	Aug.	2, 1887	1886	Deeply but sparsely pitted	
108	95	3	N.V.	.....	53	Aug.	10, 1887	1837	Markedly pitted	
109	108	3	N.V.	.....	25	Aug.	27, 1887	1865	Much pitted	
110	109	3	N.V.	.....	26	Aug.	27, 1887	1865	Pitted, not severely	
111	151	3	N.V.	.....	49	May	10, 1888	1842	Much scarred	
112	176	3	N.V.	.....	38	Oct.	25, 1888	1853	Pitted	4
113	215	3	N.V.	.....	39	Mar.	26, 1889	1853	Scarred with large scars on face	4
114	218	3	Inf.	0	31	April	3, 1889	1861	Slightly marked	
115	245	3	N.V.	.....	23	Aug.	8, 1889	1869	Sparsely, but area of scar large	3 *b*
116	250	3	Inf.	0	22	Aug.	21, 1889	1870	Very slightly scarred	1
117	252	3	Inf.	0	19	Aug.	21, 1889	1873	Sparsely, but area of scars large [nose	3 *b*
118	324	3	N.V.	.....	29	June	26, 1890	1864	Considerably pitted, especially about	3
119	332	3	Inf.	2 very indistinct	26	Oct.	15, 1890	1867	Considerably scarred	3
120	333	3	Inf.	0	24	Oct.	15, 1890	1869	Moderately pitted	3

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121	339	3	Inf.	0	36	Nov. 18, 1890	1857	Sparsely, though deeply scarred	3 *b*
122	345	3	N.V.	.....	26	May 7, 1891	1867	Considerably scarred	3
123	374	3	Inf.	4 fovs.	26	May 10, 1892	1869	Slightly pitted	2
124	378	3	3 years old.	0	28	July 19, 1892	1867	Area of scars small, but fairly numerous	
125	385	3	N.V.	.....	24	Oct. 25, 1892	1870	Severely scarred	5
126	392	3	N.V.	.....	28	Jan. 26, 1893	1868	Scarred on face	3
127	405	3	N.V.	.....	25	June 8, 1893	1871	Severely scarred	5
128	430	3	N.V.	.....	26	Mar. 20, 1894	1871	Severely pitted	5
129	455	3	N.V.	.....	31	Jan. 7, 1895	1867	Large area, sparsely pitted	3 *b*
130	46	3·5	N.V.	.....	35	Mar. 22, 1887	1853	Markedly pitted	
*131	8	4	Inf.	4 indistinct and plain scars	22	Mar. 17, 1885	1866	Face not badly, but distinctly marked	
132	27	4	Inf.	0	24	Dec. 27, 1886	1866	Pitted distinctly	
133	53	4	N.V.	.....	35	May 3, 1887	1856	Slightly pitted	
134	67	4	N.V.	.....	50	June 2, 1887	1841	Much pitted	
135	125	4	N.V.	.....	24	Nov. 2, 1887	1867	Slightly scarred	
136	127	4	N.V.	.....	30	Nov. 10, 1887	1861	Face scarred	
137	141	4	N.V.	.....	45	Jan. 25, 1888	1847	Marked on face	
138	142	4	N.V.	.....	56	Feb. 1888	1836	Much marked	
139	147	4	Inf.	0	25	April 26, 1888	1867	Sharply scarred	
140	179	4	Inf.	0	24	Nov. 6, 1888	1880	Markedly scarred	3 *a*
141	180	4	N.V.	.....	26	Nov. 6, 1888	1846	Severely pitted	5
142	184	4	N.V.	.....	54	Nov. 15, 1888	1838	Scarred	3
143	203	4	Inf.	0	28	Feb. 13, 1889	1865	Considerably scarred	3
144	219	4	Inf.	0	29	Aug. 15, 1889	1864	Largely, but sparsely scarred	3 *b*
145	280	4	N.V.	.....	32	Jan. 14, 1890	1861	Pitted	3
146	289	4	N.V.	.....	26	Feb. 6, 1890	1868	Scars large, but sparsely scattered	3 *b*
147	354	4	Inf.	0	32	July 27, 1891	1863	Scarred	3
148	383	4·5	N.V.	.....	21	Oct. 13, 1892	1873	?	
149	54	5	N.V.	.....	29	May 3, 1887	1853	Pitted, but not deeply	

150	105	5	N.V.	.....	28	Aug.	23, 1887	1864	Scarred	
151	126	5	N.V.	.....	67	Nov.	3, 1887	1825	Slightly scarred	
152	134	5	N.V.	.....	34	Dec.	14, 1887	1860	Slightly scarred	
153	153	5	N.V.	.....	32	May	29, 1888	1861	Slightly scarred	
154	159	5	Inf.	0	31	July	4, 1888	1862	Much pitted	4
155	167	5	N.V.	.....	28	July	24, 1888	1865	Slightly scarred	2
156	178	5	Inf.	0	38	Nov.	6, 1888	1854	Much pitted	4
157	190	5	Inf.	0	27	Dec.	4, 1888	1866	Much pitted	4
158	192	5	N.V.	.....	23	Jan.	9, 1889	1871	Large area	3 *b*
159	214	5	N.V.	.....	39	Mar.	19, 1889	1855	Sparsely, but sharply scarred	3 *a*
160	235	5	N.V.	.....	38	July	9, 1889	1856	Distinctly pitted	3
161	320	5	N.V.	.....	37	May	22, 1890	1858	Slightly marked	2
162	338	5	N.V.	.....	35	Nov.	11, 1890	1860	Moderately pitted	3
163	343	5	N.V.	.....	60	Jan.	7, 1891	1836	Considerably marked	3
164	353	5	N.V.	.....	30	July	27, 1891	1866	Much pitted	4
165	356	5	N.V.	.....	34	Aug.,	1891	1872	Pitted	3
166	371	5	Inf.	0	24	April	21, 1392	1873	Severely pitted on face	5
167	398	5	N.V.	.....	34	Mar.	7, 1893	1864	Pits tolerably numerous	2
168	408	5	N.V.	.....	50	June	20, 1893	1848	Severely pitted	5
169	413	5	Inf.	0	32	Aug.	17, 1893	1866	Area of scars small, but deep; not numerous	3 *a*
170	431	5	N.V.	.....	28	Mar.	21, 1894	1866	Severely pitted	5
171	438	5	N.V.	.....	40	June	21, 1894	1859	Slightly scarred	2
172	38	5·5	N.V.	.....	46	Feb.	15, 1887	1866	Slightly scarred	3
173	352	5·5	N.V.	.....	38	July	25, 1891	1858	Pitted	
174	50	6	N.V.	.....	33	Mar.	25, 1887	1870	Pitted, but not severely	
175	57	6	N.V.	.....	27	May	10, 1887	1866	Slightly pitted	
176	88	6	N.V.	.....	34	July	30, 1887	1859	Not severely scarred	
177	98	6	N.V.	.....	28	Aug.	17, 1887	1865	Scarred on face	
178	114	6	Inf.	1 plain very indistinct	30	Sept.	13, 1887	1871	Small scattered, but deep pits	
179	121	6	Inf.	1 slightly fov.	29	Oct.	20, 1887	1864	Slightly pitted	
180	155	6	Inf.	1	35	May	31, 1888	1859	Deeply scarred, damage to left eye	2
181	166	6	Inf.	0	28	July	24, 1888	1866	Slightly scarred	2
182	284	6	N.V.	.....	25	Jan.	30, 1890	1871	Scarred lightly	2
183	294	6	N.V.	.....	25	Feb.	13, 1890	1870	Pitted on face, not severely	3
184	315	6	Inf.	0	31	May	13, 1890	1865	Marked	3
185	404	6	Inf.	0	28	May	25, 1893	1871	Face scarred	

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186	411	6	N.V.	.....	27	July 20, 1893	1872	Pitted perceptibly	3
187	418	6	N.V.	.....	32	Oct. 24, 1893	1867	Much scarred	4
188	244	6·5	N.V.	.....	34	July 30, 1889	1862	Severely marked	5
189	440	6·5	Inf.	0	28	July 9, 1894	1859	Considerably pitted	3
190	40	7	Inf.	1	35	Feb. 15, 1887	1859	Not recorded	
191	79	7	N.V.	.....	31	July 7, 1887	1863	Deeply scarred	
192	110	7	N.V.	.....	31	Aug. 30, 1887	1863	Severely scarred	
193	137	7	N.V.	.....	47	Jan. 10, 1888	1847	Markedly pitted	
194	157	7	N.V.	.....	57	June 21, 1888	1839	Considerably scarred	3
195	188	7	N.V.	.....	45	Nov. 20, 1888	1850	Scarred	3
196	217	7	Inf.	2 large irregular	22	Mar. 27, 1884	1874	Slightly marked	2
197	228	7	Inf.	0	54	May 16, 1889	1842	Slightly marked	2
198	234	7	N.V.	.....	37	July 3, 1889	1850	Scarred, with large area of pock-marks	3
199	305	7	Inf.	0	26	April 15, 1890	1871	Small, but numerous pits	4 *a*
200	323	7	Inf.	0	24	June 11, 1890	1873	Much pitted	4
201	334	7	N.V.	.....	26	Oct. 15, 1890	1871		
202	350	7	N.V.	.....	49	July 27, 1891	1849	Pitted	3
203	355	7	N.V.	.....	36	July, 1891	1862	Considerably scarred	3
204	357	7	Inf.	0	29	Aug., 1891	1869	Small, but numerous pits	4 *a*
205	373	7	Inf.	0	26	May 10, 1892	1870	Sparsely, but largely scarred	3 *b*
206	384	7	Inf.	0	25	Oct. 13, 1892	1874	Very severely pitted	6
207	391	7	Inf.	2 fov.	20	Jan. 25, 1893	1882	Pitted slightly	2
208	436	7	N.V.	.....	33	May 29, 1894	1868	Sparsely, but area of scar large	3 *b*
209	449	7	N.V.	.....	33	Nov. 1, 1894	1868	Sparsely, but area of scar large	3 *b*
210	198	7·5	Inf.	0	32	Jan. 31, 1889	1864	Slightly pitted	2
211	28	8	N.V.	.....	20	July 23, 1886	1870	Deeply pitted	
212	52	8	N.V.	.....	28	Mar. 30, 1887	1867	Pitted	
213	68	8	Inf.	1 very faint and indistinct.	43	June 14, 1887	1852	Slightly marked	
214	102	8	N.V.	.....	28	Aug. 23, 1887	1867	Face much scarred	

215	160	8	Inf.	0	23	July	4, 1888	1873	Slightly scarred	2
216	173	8	Inf.	1 fov. well marked	28	Oct.	2, 1888	1868	Severely scarred	4
217	204	8	N.V.	.....	37	Feb.	20, 1889	1860	Considerably scarred	3
218	211	8	N.V.	.....	35	Mar.	19, 1889	1862	Not severely pitted	2
219	225	8	N.V.	.....	28	May	7, 1889	1869	Sparsely scarred, but area large	3 *b*
220	267	8	Inf.	0	34	Oct.	8, 1889	1863	Slightly marked	2
221	277	8	Inf.	0	26	Nov.	12, 1889	1871	Slightly marked	2
222	296	8	Inf.	0	24	Feb.	25, 1890	1874	Slightly marked	2
223	347	8	Inf.	0	45	May	19, 1890	1854	Slightly marked	2
224	367	8	N.V.	.....	21	Mar.	1, 1892	1879	Considerably scarred	3
225	375	8	N.V.	.....	40	May	19, 1892	1860	Face much scarred	5
226	419	8	N.V.	.....	27	Oct.	26, 1893	1874	Slightly pitted	1
227	420	8	Inf.	0	15	Oct.,	1893	1886	?	
228	442	8	Inf.	0	32	Aug.	21, 1894	1870	Considerably pitted	3
229	450	8	Inf.	0	26	Nov.	1, 1894	1876	Severely scarred	5
230	456	8	N.V.	.....	48	Jan.	9, 1895	1865	...	3 *b*
231	11	9	N.V.	.....	9	April	10, 1885	1885	Both eyes lost entirely; face disfigured; most of hair gone	
232	24	9	Inf.	2 faint and indistinct	30	Dec.	30, 1885	1881	Scarred on face	
233	29	9	N.V.	.....	30	Jan.	8, 1887	1866	Much marked	
234	118	9	N.V.	.....	25	Sept.	27, 1887	1878	Badly pitted	
235	135	9	N.V.	.....	33	Dec.	24, 1887	1863	Considerably marked	
236	197	9	Inf.	3	25	Jan.	31, 1889	1873	Pitting distinct and moderately thick	3 *a*
237	251	9	Inf.	0	45	Aug.	21, 1889	1853	Slightly scarred	1
238	286	9	N.V.	.....	28	Feb.	4, 1890	1869	Much scarred	4
239	295	9	Inf.	0	23	Feb.	19, 1890	1876	...	3 *b*
240	409	9	Inf.	0	33	July	19, 1893	1869	Severely pitted	5
241	432	9	N.V.	.....	25	Mar.	27, 1894	1878	Severely pitted	5
242	439	9	Inf.	0	24	June	21, 1894	1879	Pitting of face; moderately large and tolerably numerous	3
243	414	9·5	Inf.	2 fov.	37	Aug.	17, 1893	1865	Slightly scarred	2
244	43	10	N.V.	.....	32	Feb.	24, 1887	1867	Slightly scarred	
245	73	10	Inf.	0	25	June	23, 1887	1872	Slightly scarred	
*246	130	10	Inf.	Not examined	23	June	29, 1887	1874	Slightly marked	
247	156	10	N.V.	.....	29	June	9, 1888	1869	Much pitted	4

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248	212	10	N.V.	.....	31	Mar. 19, 1889	1865	Not severely pitted	2
249	221	10	Inf.	2	18	April 16, 1889	1881	Slightly scarred	2
250	248	10	Inf.	0	21	Aug. 15, 1889	1878	Much scarred	5
251	253	10	N.V.	.....	30	Aug. 20, 1889	1869	...	3 *b*
252	257	10	N.V.	.....	40	Sept. 24, 1889	1859	Scarred	3
253	268	10	N.V.	.....	22	Oct. 9, 1889	1877	Scarred	3
254	282	10	N.V.	.....	49	Jan. 14, 1890	1850	Severely pitted	5
255	321	10	Inf.	0	21	May 22, 1890	1879	Much pitted	4
256	435	10	Inf.	3 very indistinct	39	April 24, 1894	1865	Irregularly scarred, with moderate disfigurement	3
257	422	10·5	N.V.	.....	43	Nov., 1893	1861	Marked, especially about upper part of face	3
258	5	11	N.V.	.....	34	Mar. 3, 1885	1861	Much pitted on face	
259	33	11	Inf.	2 faint	33	Feb. 1, 1887	1865	Pitted perceptibly	
260	80	11	Inf.	1	24	July 7, 1887	1874	Not deeply pitted	
261	144	11	Inf.	1 indistinct scar	38	Feb. 22, 1888	1861	Not much marked. This patient is said to have had a second attack of small-pox in 1881.	
262	161	11	Inf.	0	26	July 12, 1888	1871	Scarred on face	4
263	219	11	N.V.	.....	18	April 10, 1889	1882	Much scarred; eye lost	4
264	325	11	N.V.	.....	16	July 2, 1890	1885	Pitted on face	3
265	340	11	N.V.	.....	45	Nov. 18, 1890	1856	Much scarred	4
266	447	11	N.V.	.....	32	Oct. 17, 1894	1873	Considerably scarred	3
267	416	11·5	Inf.	3 well marked and very good	20	Aug. 31, 1893	1885	Slightly marked	2
268	7	12	N.V.	.....	36	Mar. 17, 1885	1860	Face much and deeply scarred	
269	37	12	Inf.	0	34	Feb. 12, 1887	1866	Slightly scarred	
270	41	12	Inf.	0	32	Feb. 16, 1887	1867	Slightly scarred	
271	47	12	Inf.	3	36	Mar. 22, 1887	1863	Slightly pitted	
272	59	12	Inf.	2 indistinct	20	June 2, 1887	1879	Very slightly pitted	
273	75	12	Inf.	3 fov.	21	June 28, 1887	1878	Heavily scarred	

*274	150	12	Inf.	? sc r	28	May 8, 1888	1872	Scarred	
275	196	12	Inf.	0		Jan. 30, 1889			
276	210	12	Inf.	0	30	Mar. 14, 1889	1871	Scarred much and unlimited	4
277	222	12	Inf.	2 not fov.	28	April 16, 1889	1873	Slightly scarred	2
278	224	12	Inf.	0	32	April 27, 1889	1869	Evidently scarred	3
279	246	12	Inf.	4 fov.	29	Aug. 13, 1889	1872	Very slightly scarred	1
280	279	12	N.V.	.....	23	Nov. 21, 1889	1878	Much pitted	4
281	370	12	N.V.	.....	23	Mar. 24, 1892	1881		3 *b*
282	372	12	N.V.	.....	24	May 6, 1892	1880	Very severely pitted	6
283	386	12	Inf.	1 fov.	27	Oct. 25, 1892	1877	Pitted on face	2
284	410	12	Inf.	4	21	July 22, 1893	1884	Pitted perceptibly	3
285	412	12	Inf.	2	35	Aug. 1, 1893	1871	Pits on face numerous, but of small area	4 *a*
286	415	12	N.V.	.....	33	Aug. 29, 1893	1872	Not much marked	2
287	417	12	N.V.	.. ...	26	Aug. 30, 1893	1879	Scarred	3
288	22	13	Inf.	3 faint cicatrices	13	Nov., 1885	1885	Much pitted	
289	31	13	Inf.	2 very faint	29	Jan. 25, 1887	1867	Markedly pitted	
290	74	13	Inf.	1	23	June 28, 1887	1877	Pitting of face thickly distributed, but small area	
291	81	13	Inf.	1 good fov.	31	July 12, 1887	1870	Slightly scarred	
292	99	13	Inf.	1 in unusual position on back of shoulder	19	Aug. 17, 1887	1881	Scarred on face	
293	169	13	N.V.	.....	29	July 31, 1888	1872	Face pitted	3
294	231	13	Inf.	3 fov. round margins	23	May 12, 1889	1879	Scarred	3
295	238	13	Inf.	0	25	July 16, 1889	1867	Scarred	3
296	288	13	Inf.	3 faint, scarcely discernible	29	Feb. 6, 1890	1874	Slightly pitted	2
297	301	13	Inf.	1 very faint	23	Mar. 18, 1890	1880	Area of pock-marks small	4
298	310	13	Inf.	1	20	April 17, 1890	1882	Slightly pitted	2
299	317	13	Inf.	3 very indistinct	26	May 13, 1890	1877	Slightly pitted	2
300	361	13	Inf.	2 very indistinct	27	Dec. 1, 1891	1877	Slightly pitted	2

No. in series.	No. in Case-book.	Age when at-tacked.	Whether vaccinated with effect before having small-pox.	If vaccinated, number and area of scars, the average diameter of scar represented by a line.	Age of patient at time of obser-vation.	Date of observation.	Year patient had small-pox.	Remarks.	
301	362	13	N.V.	.....	49	Jan. 12, 1892	1856	Much pitted	4
302	387	13	Inf.	4 slightly fov.	24	Nov. 17, 1892	1881	Slightly pitted	2
303	433	13	Inf.	1 fov.	29	April 17, 1894	1878	Slightly pitted	2
304	453	13	Inf.	5	23	Jan. 2, 1895	1885	Slightly marked	1
305	19	14	Inf.	4	27	Aug. 5, 1887	1872		
306	51	14	N.V.	.....	33	Mar. 25, 1887	1868	Slightly pitted	
307	78	14	N.V.	.....	25	July 6, 1887	1876	Scarred very perceptibly	
308	93	14	Inf.	2 plain and indistinct scars	35	Aug. 4, 1887	1866	Slightly marked	
309	136	14	N.V.	.....	23	Dec. 27, 1887	1878	Very badly pitted	
310	233	14	Inf.	2	19	June 26, 1889	1884	Slightly scarred, but has lost left eye from small-pox	4*a*
311	243	14	Inf.	3	24	July 27, 1889	1869	Slightly marked	2
312	259	14	Inf.	0	28	Oct. 1, 1889	1875	Slightly scarred	2
313	276	14	Inf.	1 not characteristic	40	Nov. 12, 1889	1863	Considerably scarred	3
314	298	14	Inf.	0	26	Mar. 4, 1890	1878	Considerably scarred	3
315	304	14	N.V.	.....	24	Mar. 27, 1890	1880	Severely pitted	5
316	349	14	Inf.	0	24	June 10, 1891	1881	Much scarred	4
317	364	14	N.V.	.....	39	Feb. 6, 1892	1867	Slightly pitted	2
318	426	14	N.V.	.....	28	Jan. 30, 1894	1880	Thickly pitted on face	3
319	434	14	Inf.	0	34	April 18, 1894	1874	Considerably marked	3
320	441	14	Inf.	0	24	July 31, 1894	1884	Very thickly pitted, but small area	4*a*
321	17	15	N.V.	.....	29	July 6, 1885	1871	Face scarred; ectropion of lower eyelid	
322	84	15	N.V.	.....	23	July 13, 1887	1879	Much pitted	
323	94	15	Inf.	0	50	Aug. 10, 1887	1852	Slightly but distinctly marked	
324	171	15	Inf.	4	?	Aug. 28, 1888	?	Thickly congregated, but small area	4*a*
325	177	15	Inf.	3	26	Oct. 25, 1888	1877	Small but numerous pits	4*a*
326	229	15	N.V.	.....	38	May 16, 1889	1889	Scarred	3

327	239	15	Inf.	0	23	July 23, 1889	1881	Severely scarred	5
328	260	15	Inf.	0	36	Oct. 1, 1889	1868	Slightly marked	2
329	291	15	Inf.	1 well marked, and fov. round margins	32	Feb. 11, 1890	1875	Small numerous scars	4*a*
330	297	15	Inf.	3 badly marked	23	Feb. 25, 1890	1881	Pitted severely	5
331	308	15	N.V.	.....	39	April 17, 1890	1866	Severely pitted	5
332	369	15	Inf.	0	36	Mar. 15, 1892	1871	Considerably scarred	3
333	379	15	Inf.	0	30	Sept. 6, 1892	1877	Considerably scarred	3
334	380	15	Inf.	3	22	Sept. 6, 1892	1885	Thickly pitted ; area of scar small	4*a*
335	390	15	Inf.	1 good scar fov.	26	Jan. 19, 1893	1882	Pitted slightly	2
336	30	16	Inf.	6 plain, well marked	33	Jan. 25, 1887	1870	Considerably scarred	
337	146	16	Inf.	1	33	April 25, 1888	1871	Scarred	
338	152	16	Inf.	0	40	May 23, 1888	1864	Slightly scarred	
339	183	16	N.V.	.....	26	Nov. 8, 1888	1878	Slightly scarred	2
340	220	16	Inf.	6 plain	33	April 11, 1889	1872	Slightly scarred	2
341	255	16	Inf.	3 indistinct	32	Sept. 26, 1889	1873	Slightly scarred	2
342	261	16	Inf.	4 plain	23	Oct. 2, 1889	1882	Severely marked ; blind both eyes	4
343	264	16	Inf.	3 faint	28	Oct. 3, 1889	1877	...	4*a*
344	287	16	Inf.	2 well marked and fov.	21	Feb. 6, 1890	1885	Very slightly scarred	1
345	307	16	Inf.	0	36	April 15, 1890	1870	Scarred on face	3
346	319	16	Inf.	0	32	May 16, 1890	1874	Slightly scarred	2
347	359	16	Inf.	1	36	Nov. 11, 1891	1871	Pitted	2
348	363	16	Inf.	1 fov.	23	Feb. 3, 1892	1885	Pitted	3
349	365	16	Inf.	0	40	Feb. 23, 1892	1868	Face considerably scarred, especially about nose	3
350	388	16	Inf.	2 faintly fov.	22	Nov. 29, 1892	1886	Slightly pitted	2
351	2	17	N.V.	.....	45	Jan. 20, 1885	1844	Face much scarred	

No. in series.	No. in Case-book.	Age when at-tacked.	Whether vaccinated with effect before having small-pox.	If vaccinated, number and area of scars, the average diameter of scar represented by a line.	Age of patient at time of obser-vation.	Date of observation.	Year patient had small-pox.	Remarks.	
352	44	17	Inf.	1	33	Mar. 10, 1887	1870	...	
353	85	17	Inf.	1 very indistinct and plain scar	32	July 16, 1887	1872	Pitted, especially in regions of freckles of face	
354	87	17	Inf.	0	32	July 19, 1887	1870	Scarred, but not badly	
355	89	17	Inf.	3 distinct	24	Aug. 2, 1887	1880	Slightly, almost imperceptibly, marked	1
356	131	17	Inf.	1 fov.	37	Nov. 22, 1887	1867	Marked	
357	145	17	Inf.	3	30	May 1, 1888	1859	Not much scarred	
358	195	17	Inf.	3	27	Jan. 17, 1889	1879	Slightly pitted	2
359	348	17	Inf.	5	37	May 31, 1891	1871	Small area, but numerous	4*a*
360	421	17	Inf.	1	30	Oct. 26, 1893	1880	Slightly pitted, especially about nose	2
361	427	17	Inf.	1	39	Jan. 13, 1894	1872	Slightly marked	2
*362	21	18	Inf.	5 days before attack of small-pox	27	Aug., 1885	1876	Pitted on face	
363	34	18	N.V.	.....	31	Feb. 1, 1887	1869	Face pitted	
364	132	18	Inf.	0	33	Dec. 13, 1887	1872	Much pitted	
365	205	18	Inf.	1 well marked	22	Feb. 21, 1889	1885	Scarring hardly perceptible	0
366	213	18	Inf.	1 fov.	24	Mar. 19, 1889	1883	Sparsely but sharply scarred	3*a*
367	241	18	Inf.	2	27	July 25, 1889	1880	Slightly marked	2
368	281	18	Inf.	1 fov.	29	Jan. 15, 1890	1878	Pitted in centre of face	3
369	300	18	N.V.	.....	48	Mar. 6, 1890	1860	Scarred	3
370	318	18	Inf.	0	27	May 16, 1890	1881	Slightly pitted	2
371	322	18	Inf.	0	38	May 22, 1890	1870	Severely pitted	5
372	402	18	Inf.	4 good fov.	28	April 27, 1893	1883	Area of scars small but numerous	3*a*
373	23	19	Inf.	0	44	Jan., 1886	1860	Not much scarred	
374	66	19	Inf.	2 fov.	34	June 16, 1887	1872	Slightly pitted	
375	70	19	Inf.	1 fov.	28	June 22, 1887	1878	Thickly but not distinctly scarred	

376	97	19	Inf.	2 fov. distinct	40	Aug. 16, 1887	1866	Slightly scarred	
377	189	19	Inf.	3 very faint and plain	34	Nov. 22, 1888	1869	Slightly pitted	2
378	293	19	Inf.	4 very faint	26	Feb. 13, 1890	1883	Scarred	3
379	302	19	Inf.	3	24	Mar. 25, 1890	1886	Pitted, especially about nose	3
380	336	19	Inf.	3 very faint	28	Oct. 29, 1890	1881	Moderately pitted	3
381	344	19	N.V.	.....	40	Jan. 24, 1891	1871	Much scarred	4
382	396	19	Inf.	5 indistinct	41	Mar. 2, 1893	1871	Severely pitted	5
383	443	19	Inf.	2 fov.	42	Aug. 22, 1894	1871	Much marked, with sinuous white lines interwoven among the scars	4
384	18	20	N.V.	.....	45	July, 1885	1860	Face scarred with variola soon after marriage	
385	60	20	Inf.	2 fov.	28	June 2, 1887	1879	Slightly pitted	
386	113	20	Inf.	2 fov.	36	Sept. 13, 1887	1871	Slightly pitted	
387	123	20	Inf.	3 fov.	28	Oct. 27, 1887	1877	Not scarred	
388	202	20	Inf.	3 slightly fov.	24	Feb. 9, 1889	1885	Considerably scarred about nose	3
389	223	20	Inf.	3 fov.	38	April 16, 1889	1871	Slightly scarred	2
390	406	20	Inf.	1	32	June 13, 1893	1881	Small area, but confluent	4*a*
391	445	20	Inf.	1	43	Aug. 28, 1894	1871	Not much disfigured	4*a*
392	100	21	N.V.	.....	27	Aug. 18, 1887	1881	Face scarred	
393	103	21	Inf.	2 slightly fov.	37	Aug. 23, 1887	1871	Face scarred	
394	162	21	Inf.	6 plain	32	July 12, 1888	1877	Slightly scarred	2
395	194	21	N.V.	.....	26	Jan. 17, 1889	1883	Severely pitted	5
396	207	21	Inf.	2	32	Feb. 26, 1889	1878	Scarred	3
397	237	21	Inf.	6 indistinct	27	July 10, 1889	1868	Slightly scarred	2
398	360	21	Inf.	0	27	Nov. 19, 1891	1885	Numerous pits, but of small area	4
399	366	21	Inf.	4 fov. well marked	27	Feb. 25, 1892	1871	Slightly marked	2
400	424	21	Inf.	5 indistinct	30	Jan. 2, 1894	1884	Not much pitted, chiefly about nose, small area	3*a*
401	428	21	Inf.	3 very faint	34	Jan. 13, 1894	1881	Slightly marked	2

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402	20	22	Inf.	3	36	Aug., 1885	1871	Pitted	
403	35	22	Inf.	2 faint and plain	35	Feb. 4, 1887	1874	Slightly scarred on face	
404	82	22	Inf.	0	29	July 14, 1887	1880	Face frightfully scarred	
405	119	22	Inf.	5	31	Oct. 4, 1887	1878	Slightly scarred	
406	139	22	Inf.	1 (?) scar	39	Jan. 17, 1888	1870	Markedly pitted	3
407	168	22	Inf.	2	26	July 26, 1888	1866	Slightly scarred	2
408	174	22	Inf.	3 fov.	26	Oct. 16, 1888	1884	Slightly scarred	2
409	175	22	N.V.	.....	38	Oct. 25, 1888	1872	Markedly pitted	3
410	395	22	N.V.	.....	52	Mar. 2, 1893	1863	Scarred	3
411	397	22	Inf.	2	30	Mar. 9, 1893	1871	Scarred on face	2
412	446	22	Inf.	4 2 fov. and 2 very indistinct	23	Aug. 29, 1894	1893	Not scarred	0
413	163	23	Inf.	3	33	May, 1888	1878	Scarred	4
414	326	23	N.V.	.....	28	July, 1890	1885	Pitted on face	3
415	15	24	Inf.	0	24	May 7, 1885	1885	Face much marked with recent small-pox	
416	216	24	Inf.	1 well marked	28	Mar. 27, 1889	1885	Much scarred	4*a*
417	309	24	Inf.	1 faintly fov.	32	April 17, 1890	1882	Pits small, but numerous	4*a*
418	329	24	Inf.	1?	30	Aug. 7, 1890	1884	Scarred, large but superficial	3
419	341	24	Inf.	1 very faint	29	Nov. 13, 1890	1885	Not recorded	
420	382	24	Inf.	0	35	Sept. 20, 1892	1881	Pitted on face, chiefly about nose	3
421	182	25	Inf.	1 plain	28	Nov. 6, 1888	1885	Small, but thickly scattered	4*a*
422	273	25	Inf.	3 faintly fov.	32	Oct. 26, 1889	1882	Slightly scarred	2
423	292	25	N.V.	.....	36	Feb. 12, 1890	1879	Severely scarred	5
424	58	26	Inf.	2 plain	36	June 2, 1887	1877	Pitted	

425	278	26	N.V.	.....	37	Nov. 21, 1889	1878	Considerably scarred	3
426	377	26	Inf.	2 imperfectly fov.	32	June 16, 1892	1886	Thickly pitted, but small area	4*a*
427	437	26	Inf.	0	24	June 21, 1894	1879	Pitting of face moderately large and tolerably numerous	3
428	9	27	N.V.	.....	27	Mar. 25, 1885	1885	Severe keratitis; face much pitted; hair gone	
429	25	27	N.V.	.....	35	July 28, 1886	1878	Scarred obviously on face, but not deeply	
430	112	27	Inf	5	36	Sept. 13, 1887	1878	Slightly marked	
431	258	27	Inf.	3 indistinct	35	Sept. 28, 1889	1881	Slightly marked	2
432	303	27	Inf.	1 plain	35	Mar. 26, 1890	1882	Slightly marked	2
433	330	27	Inf.	2 indistinct	33	Aug. 12, 1890	1884	Small area, but very numerous	4*a*
434	368	27	Inf.	2 distinct fov.	29	Mar. 2, 1892	1890	Very much scarred	4
435	240	28	Inf.	4	45	July 25, 1889	1872	Slightly marked	2
436	263	28	Inf.	2 very faint	36	Oct. 3, 1889	1881	Slightly marked	2
437	56	29	Inf.	1 faint	34	May 11, 1887	1882	Pitted	
438	140	29	Inf.	0	49	Jan. 17, 1888	1868	Sight of right eye gone and deaf in left ear from small-pox; very much disfigured	
439	400	29	Inf.	3	40	April 6, 1893	1883	Face marked irregularly; tolerably numerous	3
440	1	30	N.V.	.....	52	Nov. 1, 1884	1862	Face much scarred	
441	4	30	Inf.	3	30	Mar., 1885	1884		
442	26	30	Inf.	3 faint	34	Dec. 8, 1887	1884	Scarred on face, not deeply	
443	138	30	Inf.	1 fov.	33	Jan. 14, 1888	1885	Severely pitted	
444	185	30	N.V.	.....	34	Nov. 15, 1888	1884	Scarred	3
445	209	30	Inf.	1	35	Mar. 14, 1889	1884	Sparsely, though sharply scarred	3*a*
446	274	30	Inf.	1 well marked, not fov.	52	Oct. 31, 1889	1859	Considerably scarred, small area	3
447	381	30	Inf.	1 very plain	41	Sept. 15, 1892	1881	White medium-sized scars, not very numerous	2
448	101	33	Inf.	2, quite plain and indistinct	39	Aug. 20, 1887	1881	Face much pitted	

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449	111	33	Inf.	0	40	Sept. 3, 1887	1880	Slightly marked	
450	61	34	Inf.	1 indistinct	45	June 4, 1887	1876	Slightly marked	
451	313	34	Inf.	4 fov.	39	May 1, 1890	1885	Considerably pitted, especially about nose	3
452	403	34	Inf.	0	49	April 25, 1893	1878	Severely pitted	5
453	55	36	N.V.	.....	62	May 10, 1887	1861	Pitted, the scars not deep, but white	
454	172	36	N.V.	.....	43	Aug. 29, 1888	1881	... .	4*a*
455	76	37	Inf.	1 fov. distinct	41	June 29, 1887	1883	Slightly marked	
456	337	38	Inf.	0	39	Nov. 11, 1890	1889	Moderately pitted	3

CASES THAT COULD OR WOULD NOT SAY THE DATE THEY HAD SMALL-POX.

†	3	?	Could not say as to vaccination	No scar	18	Mar. 3, 1885	?	Much pitted on face	
†	13	?	Not	.....	4½	April 28, 1885	?	Left eye destroyed	
†	14	?	?	?	?	April 28, 1885	?	Blind from small-pox	

Table VII.

Admittedly unvaccinated.	Stated to have been vaccinated, but having no scars.	Having 1 scar.	Having 2 scars.	Having 3 scars.	Having 4 scars.	Having 5 or more scars.
Days.	Days.	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
7	...	...	...	...	...	...
14	..	...	...	...	...	...
21	21	...	...	...	...	...
28	...	...	...	...	...	...
35	...	...	...	...	...	...
42	...	...	...	...	...	...
42	...	...	..	...	...	...
42	...	...	...	...	...	...
42	...	...	...	...	...	...
42	...	...	...	...	...	...
49	...	...	...	...	...	...
61	61	...	...	...	...	...
63	...	...	...	...	...	...
90	90	...	...	...	...	...
91	91	...	...	...	...	...
106	92	...	...	...	...	...
122	...	...	...	...	...	...
122	152	...	...	...	...	...
182	...	..	...	...	...	...
182	..	...	...	...	...	...
182	...	...	...	...	...	...
183	...	...	...	..	...	...
183	...	...	...	...	...	...
183	...	...	...	...	...	...
213	...	...	...	...	...	...
213	...	...	...	...	...	...
274	...	...	...	...	...	...
274	...	...	...	...	...	...
275	...	...	...	...	...	...
304	...	...	..	...	...	...
304	...	...	...	...	...	...
304	...	...	...	...	...	...
335	.	...	...	...	...	...
335	...	...	...	...	...	...
		...	...	...	...	...
Years.	Years.	...	...	...	...	...
1	1	...	...	...	...	...
1	1	...	...	...	...	...
1	1	...	...	...	...	...
1	1	...	...	...	...	...
1	1	...	...	...	..	...
1	1	..	...	...	...	...
1	1	...	...	...	...	...

Admittedly unvaccinated.	Stated to have been vaccinated, but having no scars.	Having 1 scar.	Having 2 scars.	Having 3 scars.	Having 4 scars.	Having 5 or more scars.
Years.	Years.	Years.				
1	1	...	...	...	...	..
1	...	...	...	...	...	...
1·16	...	...	...	...	...	...
1·33	...	...	...	...	...	...
1·5	1·5	...	...	...	...	...
1·5	1·5	...	...	...	...	...
1·83	1·5	...	...	...	...	...
2	2	2	...	...	...	..
2	2	...	...	...	..	...
2	2	...	...	...	...	...
2	2	...	...	...	...	...
2	2	...	...	...	...	...
2	2	...	...	...	...	...
2	...	...	...	...	...	...
2	...	...	...	...	...	...
2	...	...	...	...	...	...
2	...	...	...	...	...	...
2	...	...	...	...	...	...
2	...	...	...	...	...	...
2	...	...	...	...	...	...
2	...	...	...	...	...	...
2	...	...	...	...	...	...
2	...	..	...	...	...	...
2	...	...	...	...	...	...
2·5	2·5	...	...	...	...	...
2·5	2·5	...	...	...	...	..
2·5	...	...	...	...	...	...
2·83	...	...	...	...	...	...
3	3	...	...	...	...	...
3	3	...	...	...	...	...
3	3	...	...	..	...	...
3	3	...	...	...	...	...
3	3	...	...	...	...	...
3	3	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	...	...
3	...	...	...	...	..	...
3	...	...	...	..	...	...
3	...	...	...	...	...	...
3·5	...	...	...	...	...	...

Admittedly unvaccinated.	Stated to have been vaccinated, but having no scars.	Having 1 scar.	Having 2 scars.	Having 3 scars.	Having 4 scars.	Having 5 or more scars.
Years.	Years.	Years.	Years.			
4	4	...	...	...	...	...
4	4	...	...	...	...	...
4	4	...	...	...	...	...
4	...	...	...	...	...	...
4	...	...	...	...	...	...
4	...	...	...	...	...	...
4	4	...	...	...	...	...
4	4	...	...	...	...	...
4	4	...	...	...	...	...
4	...	...	...	...	...	...
4·5	...	...	...	...	...	...
5	5	...	...	...	...	...
5	5	...	...	...	...	...
5	5	...	...	...	...	...
5	5	...	...	...	...	...
5	5	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5	...	...	...	...	...	...
5·5	...	...	...	...	...	...
5·5	...	...	...	...	...	...
6	6	6	...	...	...	...
6	6	6	...	...	...	...
6	6	6	...	...	...	...
6	...	...	...	...	...	...
6	...	...	...	...	...	...
6	...	...	...	...	...	...
6	...	...	...	...	...	...
6	6·5	...	...	...	...	...
6·5	...	...	...	...	...	...
7	7	7	7	...	...	...
7	7	...	7	...	...	...
7	7	...	...	...	...	...
7	7	...	...	...	...	...
7	7	...	...	...	...	...
7	7	...	...	...	...	...
7	...	...	...	...	...	...
7	...	...	...	...	...	...
7	...	...	...	...	...	...
7	...	...	...	...	...	...

Admittedly unvaccinated.	Stated to have been vaccinated, but having no scars.	Having 1 scar.	Having 2 scars.	Having 3 scars.	Having 4 scars.	Having 5 or more scars.
Years.	Years.	Years.	Years.	Years.	Years.	Years.
7	7·5	...	...	...	...	...
8	8	8	...	...	...	...
8	8	8	...	...	...	...
8	8	...	..	...	...	...
8	8	...	...	...	...	...
8	8	...	...	...	...	...
8	8	...	...	...	...	...
8	8	...	...	...	...	...
8	8	...	...	...	...	...
8	...	..	...	...	...	...
8	...	..	...	..	...	...
9	9	...	9	9	...	...
9	9	...	...	...	...	...
9	9	...	...	...	...	...
9	9	...	...	...	. .	...
9	...	...	...	...	...	...
9	...	...	9·5	...	...	...
10	10	...	10	...	...	...
10	10	...	...	...	...	...
10	10	...	...	...	...	...
10	...	...	...	...	...	...
10	10	...	...	10	...	...
10	...	...	...	...	...	...
10	...	...	...	...	...	...
10·5	...	...	...	...	...	...
11	11	11	11	...	...	...
11	...	11	...	...	...	...
11	...	...	...	...	...	...
11	...	...	...	...	...	...
11	...	...	...	11·5	...	...
12	12	12	12	12	12	...
12	12	...	12	12	12	...
12	12	...	12	...	...	...
12	12	...	..	...	...	...
12	12	...	...	...	...	...
12	12	...	...	...	...	...
13	13	13	13	13	13	13
13	...	13	...	13	...	...
14	14	13	14	13	...	...
14	14	13	14	13	...	...
14	14	13	...	14	14	16
14	14	13	...	...	...	...
14	14	14	...	...	...	...
14	...	15	...	15	15	...
15	15	15	...	15	...	...
15	15	16	...	15	...	...
15	15	16	16	16	16	16
15	15	16	16	16	...	...
16	15	17	...	17	...	...
17	16	17	...	17	...	...

Admittedly unvaccinated.	Stated to have been vaccinated, but having no scars.	Having 1 scar.	Having 2 scars.	Having 3 scars.	Having 4 scars.	Having 5 or more scars.
Years.	Years.	Years.	Years.	Years.	Years.	Years.
...	16	17	...	17	...	17
...	16	...	...	...	...	...
...	16	...	...	...	...	...
...	17	...	...	...	...	...
18	18	17	18	19	18	19
18	18	17	19	19	19	21
19	18	18	19	19	21	21
20	19	18	19	20	22	21
21	21	18	20	20	28	22
21	22	19	20	20	34	27
22	24	20	21	21	...	...
22	24	20	21	22	...	...
23	26	22	22	22	...	...
25	29	24	22	23	...	...
26	33	24	22	25	...	...
27	34	24	26	27	...	...
27	38	24	26	29	...	...
30	...	25	27	30	..	...
30	...	27	27	30	...	...
36	...	29	28	...	...	...
36	...	30	33	...	...	...
...	...	30	...	...	...	...
...	...	30	...	...	...	...
..	...	30	...	...	...	...
...	...	34	...	...	...	...
...	...	37	..	...	...	...
1382	952·64	835	552·5	594·5	224	193
210 cases, average = 6·58 years.	105 cases, average = 9·07 years. 9·86*	47 cases, average = 17·77 years.	31 cases, average = 17·82 years.	33 cases, average = 18·02 years.	12 cases, average = 18·67 years.	10 cases, average = 19·3 years.

The more reasonable opponents of vaccination admit the decrease of small-pox at the present time, but explain the decrease in two ways. They say, first, that improved sanitary conditions have occasioned it. We will admit that to a very limited extent this is true, but if it be the main reason then surely the other zymotic diseases should also have declined in some such way as small-pox. From Table V. it will be seen that, instead of decreasing, they

* This lower figure is the corrected age. (See p. 9.)

seem to have absolutely increased, moreover in the one disease, whose death ages are analyzed by Dr. Percival in the last century, viz., measles. See Table VIII.

Table VIII.

AGE AT DEATH FROM MEASLES AT MANCHESTER, FROM 1760 TO 1774, COLLECTED FROM THE REGISTER OF THE COLLEGIATE CHURCH.

Age 0-1	Age 1-5	Age 5-20	Age 20-40	Age 40-60	Age 60-80
15 16·48	72 79·12	4 4·40	0 —	0 —	0 —

We see that 95·6 per cent of individuals who died of measles were under 5 years of age in the last century.

Table IX.

AGE AT DEATH FROM MEASLES IN LONDON DURING THE PERIOD 1890 TO 1894.

Age 0-1	Age 1-5	Age 5-20	Age 20-40	Age 40-60	Age 60-80
2,747 20·43	9,916 73·75	751 5·59	28 ·21	2 ·02	1 ·007

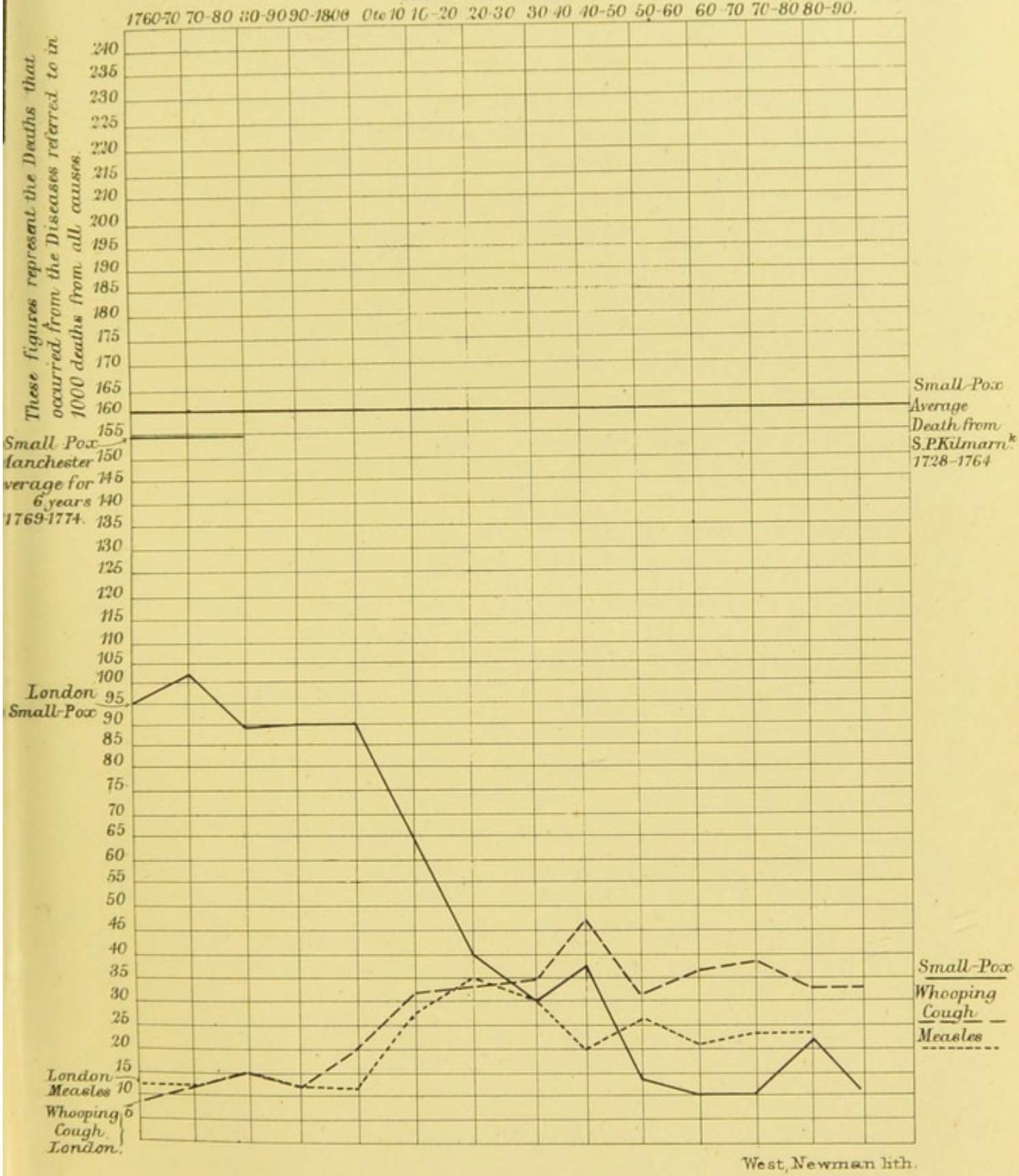
From Table IX. we see that 94·18 per cent. deaths from measles take place at the present day in children under 5 years of age; in fact, very nearly the same as in the last century—a very different state of things from what we have seen to be the case with small-pox.

That to have had small-pox in infancy was as common in pre-vaccination times as it is at the present day to have had measles in infancy, may be inferred from the condition of things in Ware.* At the time we are speaking of, viz., 1722, Ware was only a village with a population of 2,515.

* See a paper in the library of the Royal Society, England.

Table V.

Diagram showing the Mortality in London from Small Pox, Measles & Whooping Cough. from 1760 to 1890.



West, Newman lith.

The registrar divided the population into three classes. The first class contained those who had had small-pox in a previous epidemic. They numbered 1,601 cases. The second class contained those who had small-pox during the then present epidemic, and these numbered 612, of which 72 died, leaving 540 alive. Therefore there were living, after the epidemic, 2,443, of which 2,141 had had small-pox, or 88 per cent., and the third class were contained under the heading of *those who have to have their small-pox.*

We may hence infer that 88 per cent. of the population of Ware, after the epidemic of 1722 were more or less pitted with the small-pox. At the present time, walking through the streets of London, we have counted 3,720 people passing by, and of these only 9 were obviously scarred, or ·24 per cent.

Some little explanation might here be given of the methods by which Table V. has been compiled, for an apparent inconsistency may to some extent be explained.

Deaths from small-pox prior to the year 1838, which was the first year that the Registrar-General's Reports were published, containing as they did certificates of death from registered medical practitioners, deaths from small-pox and other diseases were previously collected from certificates which the law compelled to be given before the body of the deceased could be buried. These certificates were given by persons whom the guardians of the poor appointed. They were called 'Searchers,' and it was their duty to inspect every dead body, and to give a certificate, as far as they were able, as to the cause of death. These certificates were sent weekly by the parish clerks, who received them on the burial, to the Company of Parish Clerks, and this company were thus able to issue a weekly publication, which went by the name of the Weekly Bills of Mortality. These bills were summarized yearly, and the summarized bills were called the General Bills.

The 'Searchers' were not medical practitioners; indeed

they were often the poorest people in the parish, for it was anything but a pleasant occupation to visit the bodies of the dead, especially those who had died of infectious diseases. The following quotations from old authors will show what has just been stated of them is correct.

From John Graunts, F.R.S., Bills of Mortality, published in 1676, p. 34.

'In the next place it shall be examined under what name or cassualty such as die of these diseases are brought in; I say, under the Consumption; foreasmuch as all dying thereof dye so emaciated and lean (their Vlcers disappearing upon Death) that the Old-women Searchers, after the mist of a cup of Ale, and the bribe of a two groat* fee, instead of one given them, cannot tell whether this emaciation or leanness were from a Phthisis or from an *Hectick Fever*, Atrophy, etc., or from an Infection of the Spermatick parts which in lenghth of time and in various disguises hath at last vitiated the habit of the Body and by disabling the part to digest their nourishment brought them to the condition of leanness above mentioned.'

Dr. Fothergill, quoted by Willan in his miscellaneous works, edited by Ashby Smith, M.D., 1821, 'Observations on the Weather and Disease,' p. 196.

Dr. Fothergill was of opinion that the number of deaths from Consumption was greatly over-rated in the Bills of Mortality; he remarks on this subject "Foreigners who are ignorant in what manner our Bills are compiled give it out that Consumption is the grand endemic of England. The Searchers are commonly two (*sic*) as poor and ignorant persons as the Parish affords; these are to see all dead bodies and to report to the Company of Parish-clerks of what disease they died; if the body is emaciated, which may happen even from an acute fever, it is enough for them to place it to the account of Consumption though the death of the party was perhaps owing to a disease specifically different; and thus a monstrous account is framed by the

* A groat=fourpence.

ignorance of the searchers, to the disgrace of our country and even so far as to discourage some foreigners from coming among us."'

It will be readily inferred how frequent errors of diagnosis must have been. However, the disease most easily recognised was small-pox, and fewest mistakes would therefore be registered under this disease. That the Bills of Mortality did not in fact over-estimate the deaths from small-pox may be inferred from the registration of disease in 1838 and 1839, for we have the registration both of the Bills of Mortality and the Registrar-General. We find that for 1838 the Bills of Mortality give 788 deaths, whereas the Registrar-General gives 3,817 deaths, but the Registrar-General's records embrace districts outside the Bills of Mortality. Now we know nearly what districts outside the Bills of Mortality contributed. They were as follows:

Kensington	253
Marylebone	199
Pancras (including Small-pox Hospital) ...	372
Camberwell	23
Greenwich	129
One-third of Poplar to represent St. Leonard, Bromley, and St. Mary, Stratford-le-Bow...	23
One-tenth of Hackney to represent St. Mary, Stoke Newington	7
	1,006

Hence, if we deduct this number from the Registrar-General's figures, 3,817 − 1,006 = 2,811, this ought to tally with the number of deaths recorded by the Bills of Mortality, but it is in fact 2,023 in excess, or the Bills register 257 per cent. too little small-pox. There is another reason to suspect that the Bills of Mortality in London under-estimated the deaths from small-pox, and that is, on referring to Table V., p. 34, it will be seen that the average small-pox deaths was higher in Kilmarnock, a then village in the south of Scotland, than it was in London. As the registration was dif-

ferent from what it was in London, the apparently higher death-rate in Kilmarnock may be more than accounted for by the errors of registration in London.

Death is the worst evil that can befall us, but there is one nearly as bad, and that is blindness. The blind institutions of the last century used to receive their greatest contingent from unfortunate people who had lost their sight from small-pox. Sir Gilbert Blane quoted a report of the Hospital for the Indigent Blind to the effect that two-thirds of those who applied there for relief had lost their sight by small-pox.*

Dr. Gregory, the superintendent of the Small-pox Hospital in 1819, writes, that a large proportion of the blind have been found to owe their misfortune to the secondary fever of small-pox.

Mr. Cross, writing of the epidemic of small-pox at Norwich in 1819, states that of 200 cases of small-pox, 3 had lost eyes from small-pox, or 1·5 per cent.

In the present day, a statement of the Christian Blind Relief Society (established in 1843) contains the names of fifty people seeking relief, blind from all causes. One of these people was blind from having had small-pox, viz., Sarah Barnes, Bethnal Green, aged 39. Small-pox hence appears to occasion 2 per cent. of the blindness at the present time. The date of the advertisement is about 1888. A copy of the statement is appended, p. 39.

Dr. Brailey has also noticed the vaccination scars of fifteen cases of people who had lost an eye from small-pox, and he found that seven were admittedly unvaccinated when they had the small-pox which blinded them. These cases were 16 out of 763 who lost eyes from all causes, which shows, as far as it goes, that 2·24 per cent. of the blindness at the present time is caused by small-pox. (See p. 40.)

* Medico-Chirurgical Transactions, vol. x., p. 326.

Statement of the Christian Blind Relief Society.

Candidates.	Age.	Address.	Cause of Blindness.
1. Mitchell, Wm. H. ...	56	Westerntown, Sidmouth	Disease of brain.
2. Smith, Stephen ...	80	St. Leonard's-on-Sea ...	Cataract.
3. Brady, Elizabeth ...	36	Darlington	Inflammation.
4. Sandiforth, Harriett ...	33	Kippax, Leeds	Glaucoma.
5. Rham, Elizabeth ...	46	Wisbeach	Detachment of retina.
6. Ballinger, Harriett ...	48	Minsterworth	Cataract.
7. Barnes, Sarah	39	Bethnal Green	Small-pox.*
8. Willard, Richard ...	74	Silverhill, Hastings ...	Cataract.
9. Lamb, Mary	64	Shepherd's Bush ...	Cataract.
10. Chatfield, Albert Edw.	51	Stoke-on-Trent	Fits in infancy.
11. Brown, John	62	Norwich	Inflammation.
12. Bayley, Charlotte ...	67	Tottenham Court Road...	Cataract.
13. Wilkinson, James ...	55	Kentish Town	Typhus fever.
14. Berry, Ellen	43	Drury Lane	Typhus fever.
15. Perrigo, Francis ...	78	Leominster	Cataract.
16. Harding, Thos. ...	84	Dursley, Gloster ...	Unknown.
17. Goodchild, Augusta ...	39½	Wells, Somerset ...	Disease of brain.
18. Savage, Christopher ...	56	St. Luke's, E.C. ...	Yellow fever.
19. Lee, Alice A. H. ...	20	Mile End	Measles.
20. Hadkinson, Eliz. ...	51	Battersea	Effects of a blow.
21. Kelynack, Charlotte ...	32	Penzance...	Illness.
22. Lucas, Grace	68	Haggerston	Cataract.
23. Bush, Fanny	46	Chichester	Constitutional.
24. Edwards, Edith ...	25	Chelsea	Atrophy of the nerves.
25. Franks, Hy. Wm. ...	28	Canterbury	Born blind.
26. Dutnall, Mary A. ...	53	Maidstone	Inflammation.
27. Cadman, Eliza ...	45	Wolverhampton ...	Cataract.
28. Winterton, Geo. ...	65	Ware	Cataract.
29. Burley, Wm.	32	S. Lambeth	Failing of optic nerve.
30. Walker, Maria ...	71	Maida Vale	Glaucoma.
31. Hayward, James ...	53	Ryde, I.W.	Constitutional.
32. Smith, Eliz.	19	Abbenhall	Hereditary.
33. Ponshaw, Hy. ...	35	Southampton	Water on the brain.
34. Puddefoot, Daniel ...	69	Hemel Hempstead ...	
35. Flipping, Emma ...	30	Camden Town	Tumour on the brain.
36. Silvester, Emma ...	43	Bristol	Abscess on brain.
37. Poynter, Emily ...	39	Orleton	Inflammation.
38. Parkes, John	46	Stoke Ferry	Disease of nerve.
39. Jennings, Geo. ...	38	Bow	Cold.
40. Smith, James	50	Newmarket	Scrofula.
41. Jaggers, Thomas ...	33	Barking	Born blind.
42. Brookes, Thos. ...	42	E. Greenwich	Lead colic.
43. Bennett, Alfred ...	35	Bethnal Green	Constitutional weakness.
44. Gaylor, Susan	39	Hatfield	Born blind.
45. Lawrence, Sarah ...	55	Preston	Disease of the optic nerve.
46. Nicholes, Wm. ...	50	Poplar	Retina destroyed.
47. Brassington, H. ...	58	Leek	Inflammation.
48. Foster, Emma ...	72	Stratford...	Unknown.
49. McCullum, Fanny ...	43	Poplar	Weakness.
50. Cosker, Thos.	73	Limehouse	Sudden strain.

* Showing that, according to this statement, small-pox even now occasions 2 per cent. of the whole total blindness.

TABLE.

A record of cases who lost eyes from small-pox out of a total of 763 *cases who lost eyes from all causes, as observed at Moorfields Hospital by Dr. Brailey.*

	No. in Case-book.	Age when attacked.	Whether vaccinated with effect before having small-pox.	If vaccinated, number of scars.	Age of patient at date of observation.	Date of removal of eye.	Year patient had small-pox.	Remarks.
1	346	Under 1 year	Not	.....	12	Nov. 12, 1878	1866	Both eyes lost.
2	*	1 year	Not	.....	18	?	1862	
3	712	1 year	Not	.....	30	?	1851	
4	841	1 year	Vacc. during incubatory period	.....	62	April 22, 1882	1820	
5	944	4 years ...	Vacc. produced only a pimple	.....	4	Oct., 1882	1882	
6	798	7 years ...	Not	.....	8	Feb. 3, 1888	1881	
7	741	12 years ...	In inf.	No scar	13	?	1880	
8	903	15 years ...	Not	.....	29	Aug. 5, 1882	1869	
9	748	16 years ...	In inf.	No scar	16	1881	1880	Holds certificate of vaccination.
10	486	17 years ...	In inf.	1 scar	21	June, 1881	1877	
11	489	19 years ...	Not	.....	24	Mar. 14, 1880	1875	
12	768	19 years ...	Not	.....	37	Dec. 7, 1881	1863	
13	498	20 years ...	In inf.	2 scars	22	?	1878	
14*								
15	222	23 years ...	In inf.	1 scar	24	July 11, 1878	1877	
16	158	37 years ...	In inf.	Has scars, but No. not stated.	38	July 3, 1887	1876	

* Imperfectly observed.

PLATE Ia.

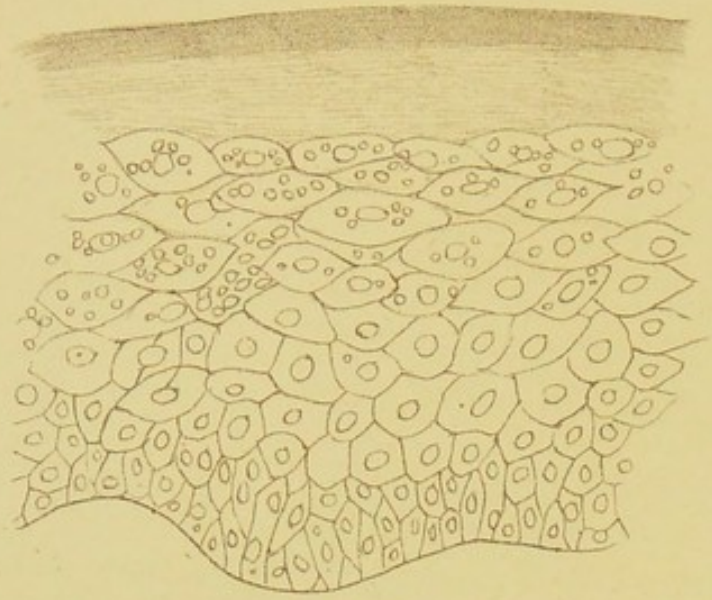


Fig. 1

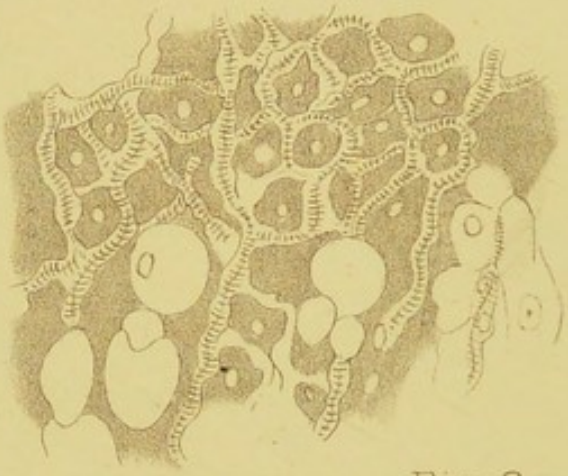


Fig. 2

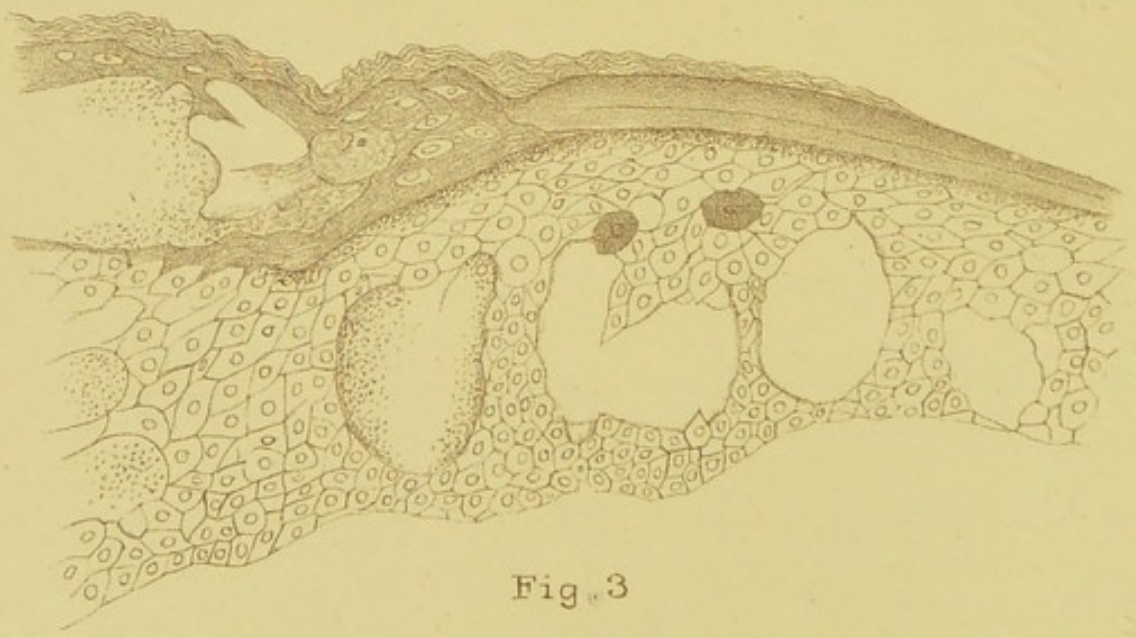


Fig. 3

West, Newman chromo

LECTURE II.

HISTOLOGY OF THE VACCINE AND SMALL-POX VESICLES.

To-day, gentlemen, I have to call your attention to the morbid anatomy of vaccinia and to that of small-pox, and I hope to establish in your minds the close anatomical changes which hold between these morbid conditions—in fact, I may say, establish their identity so far as their morbid anatomy is concerned. I shall also step over our strict boundary to say a few words about the morbid anatomy of chancre, and I hope to be able to show you how utterly different are the minute changes which take place during the development of the syphilitic chancre. I should not have alluded to this last-mentioned disease if it had not been recently affirmed by a gentleman, who is essentially an anti-vaccinator, though, I believe, he does not admit as much. Dr. Crighton is referred to. He implies that every vaccination vesicle is a lesion of a syphilitic nature.

Before we enter upon a discussion of the morbid changes which take place after vaccination, it may be convenient to review the normal histology of the special seat of lesion, viz., the skin, and I shall adopt Dr. Klein's nomenclature.

First, then, we find the external cuticle, epidermis, or scarf-skin; this layer is called by Klein the stratum corneum. (See Plate I., *a*.) It is that portion of the skin which is raised from the rest when a blister is applied. It is also

that part which becomes detached when the dead skin is macerated, as when the body of a man has been in water a week or two, or the fœtus has suffered intra-uterine death and not been shortly expelled. Immediately below this may be seen the stratum lucidum; it is a thin homogeneous layer, the component cells of which are only indistinctly seen in some sections, and the nuclei have disappeared. (See Plate I., *b*.)

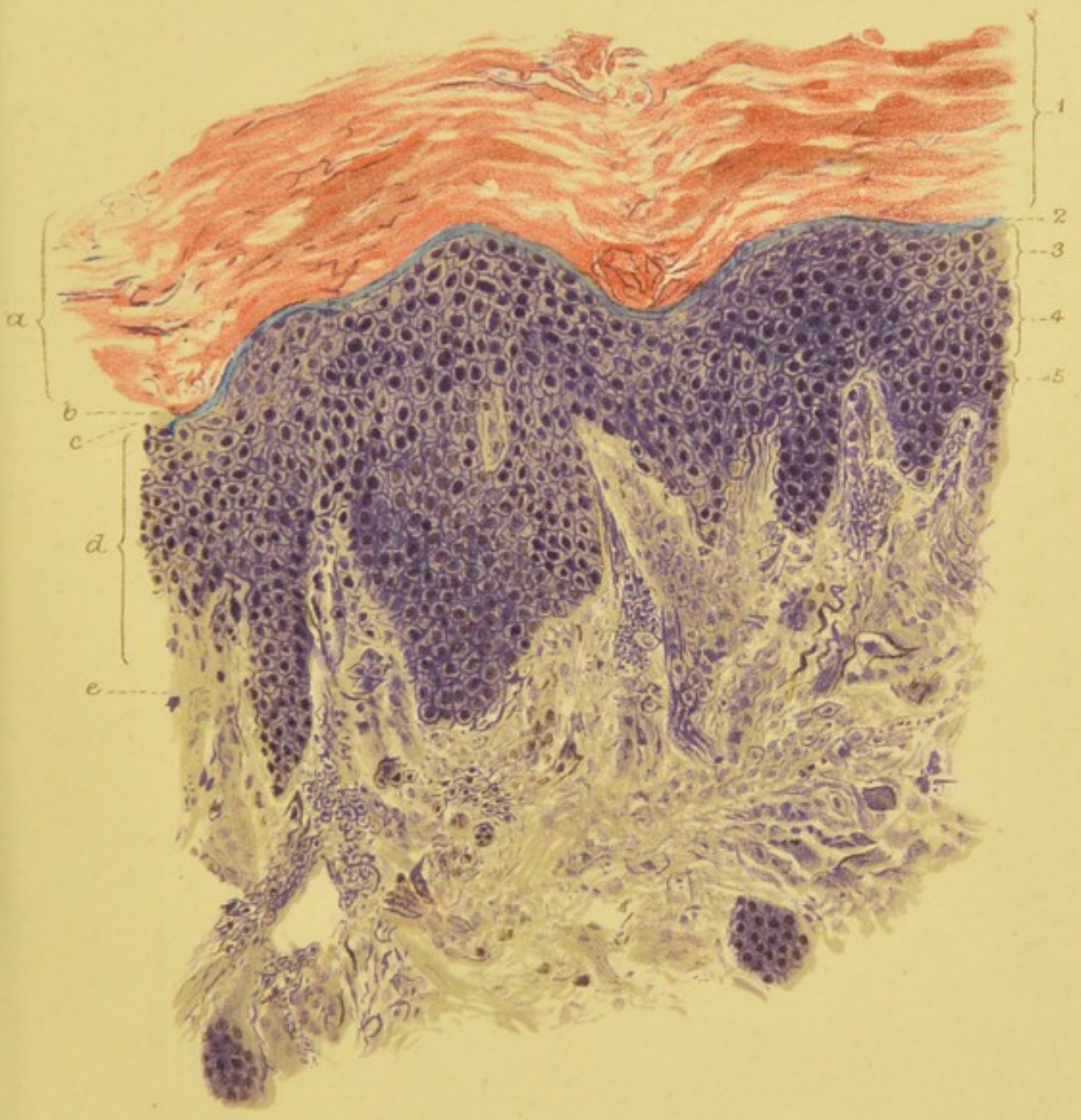
The next layer is the granular layer of the rete Malpighii (Langerhaus). It consists of flattened cells, with a nucleus and granules. The granules are chiefly to be seen at the poles of the nucleus, gradually diminishing in size as they extend outwards. (See Plate I., *c*.)

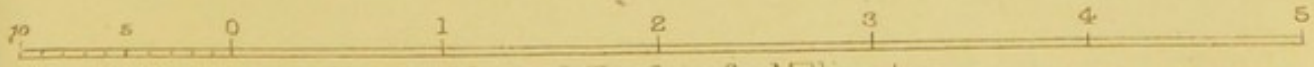
The next layer of the rete Malpighii (see Plate I., *d*.) is a more or less stratified layer, of which the more superficial cells are flattened together with their nuclei. In the succeeding layers the cells and their nuclei are rounder. The cells are connected with each other by fine filaments, the so-called prickle cells (Max Schultze). (See Plate I., *a*, Fig. 2.) Lastly, in the deepest layer the cells are columnar, with oval nuclei. These latter rest upon the cutis vera or corium. (See Plate I., *e*.)

Thus far only need we minutely describe the epidermis. The pathological changes which take place after a successful vaccination are: first, there is an increase of intercellular fluid, especially between the round epithelial cells of the rete Malpighii, probably on account of this increase of the fluid or nourishing material; you have an increased formation of cells, and an increase in size of individual cells. These three increases, viz., the increase of the intercellular fluid, the increase in the formation of cells, and the increase in size of many of the cells, together constitute the hard red papule, which feels like a shot underneath the skin. This stage is called the papular stage. The papule grows in area, encroaching more and more on the healthy skin centrifugally, while in the centre, owing to the large amount of intercellular fluid and the rupture of some of the large

PLATE I.

1. *Stratum corneum.*
2. *Stratum lucidum.*
3. *Superficial layer of rete malpighii including granular cell layer.*
4. *Middle layer of rete malpighii.*
5. *Deep layer of do.*

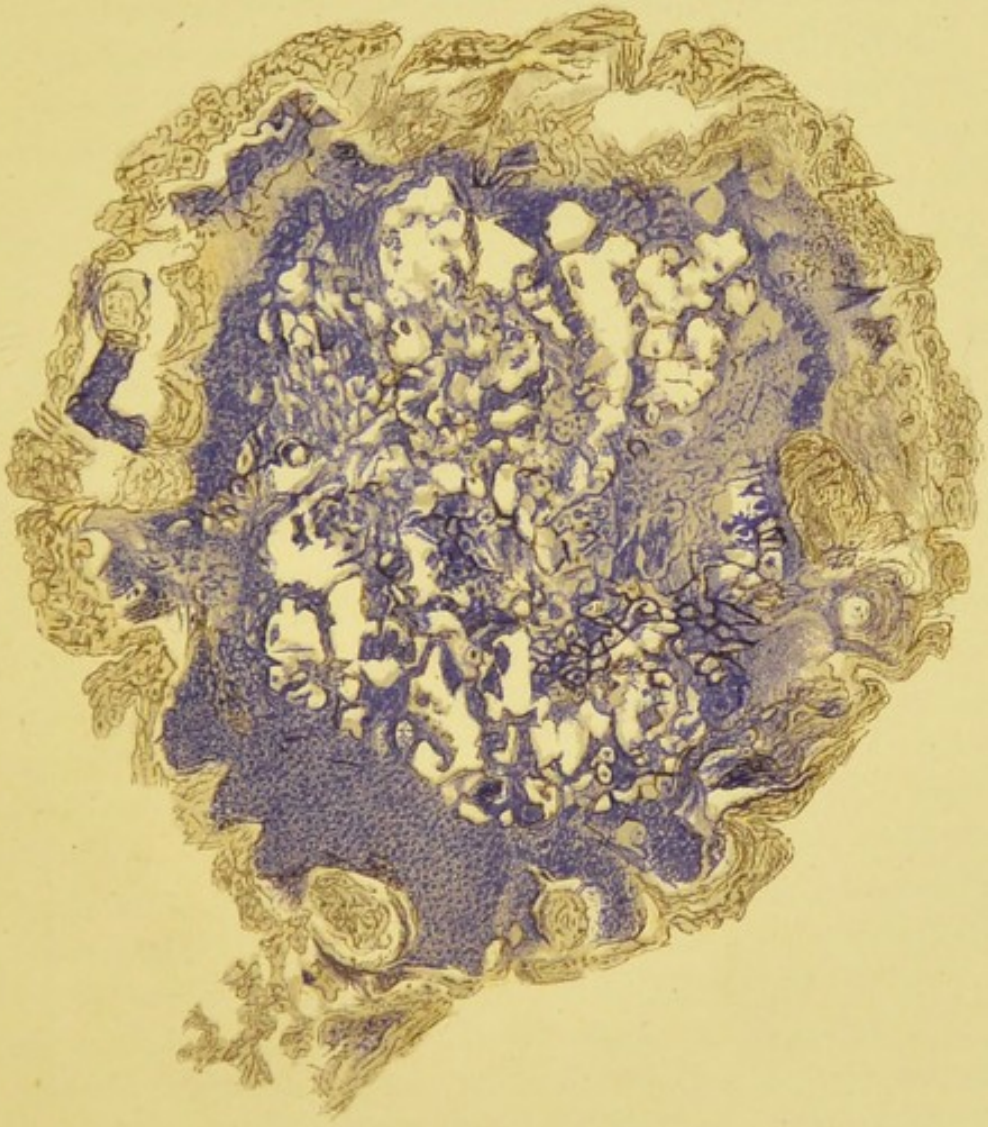




Hundredths and Tenths of a Millimetre.

West, Newman chromo.

PLATE II.



West, Newman chromo.

cells, vacuoles, as they have been called, are formed. They, however, are full of the vaccine lymph. (See Plate I., *a*, Fig. 3.) Some of the cells do not burst, but are more or less distorted from pressure and tension, becoming spindle-shaped. These elongated cells, lying in juxtaposition with one another, form the walls of the vacuoles, and are, in fact, the dissepiments of the vesicle, for the vaccine vesicle is not like a pustule, from which, when pricked in one place, all the pus can be extracted from this one opening. Not so, however, the vaccine vesicle ; for this must be pricked in many places, on account of these dissepiments, before much lymph can be obtained. The vaccine vesicle is more of a honeycombed structure rather than a pouch. (See Plate I., *a*, Fig. 3.) These changes take place first at the site of vaccination, and, as I have said, gradually extend outwards, the newly-invaded portion of the skin going through the same changes as did that of the centre ; but as the vesicle extends outwards other changes take place at the centre. The vacuoles here, at first large, become smaller, cell growth ceases, and the enlarged cells begin to shrink, so that if a section be made at this stage of the vesicle's growth on a plane parallel with the surface of the skin, it will have the appearance represented in Plate II.

The ordinary description of the vesicle consisting of radiating dissepiments, like those of an orange, is quite imaginary, for there is really no regularity about their deposition. It is true the vacuoles in the centre, or those which were first formed, are smaller, from absorption of the fluid, than the later formed ones at the circumference, and this may have given systematists the idea that the vesicle consists of radiating divisions. And, further, the puckered condition of some vaccine scars may have confirmed this impression ; but the puckering of the scar, when it exists, is not from the remains of these fanciful radiating dissepiments, but from the severity of the inflammatory progress of the disease, the whole thickness of the skin having been involved, and the consequent contraction of the resulting

cicatrix. The formation of these vacuoles, as we have described, continues until the vesicle has finished enlarging, and this stage of the development of the vesicle we may call the vesicular stage. Before, however, the vesicle has quite ceased to grow, an inflammation of the skin adjacent to the vesicle begins to appear, first immediately round the vesicle, and generally extends when at its height to more than an inch in extent around the vesicle. This inflammation or areola, as it is called, usually begins early on the eighth day, and may begin earlier if the vesicle be advanced, or later if the vesicle be retarded, or may even scarcely appear at all, if the child has taken mercury some days before and continues taking it during the course of vaccination. Hence, a total absence of all areola on the eighth day is to be looked upon with suspicion. This areola is at its height on the tenth day after primary vaccination, and then begins to decline. At this stage of the vesicle a second or new stratum lucidum begins to form (Plate III., *c*), at first at the margins of the vesicle, and subsequently over its whole area. The old stratum lucidum forms the external-limiting membrane of the vesicle, for the stratum corneum is generally shed and separates from the stratum lucidum, leaving this, as we have already said, the external limiting membrane. The new stratum lucidum forms over the bottom of the vesicle. It is really the beginning of the process of healing, and is, in fact, the first formation of the new skin beneath the vesicle, and all the tissues between the two strata lucida dry up and constitute the thick dark scab which forms over the site of vesiculation. This is the reason why, after vaccination, the scab that forms is so thick.

If nothing is placed on the wound to prevent the scab drying up as it naturally should, and the healing process goes on uninterruptedly, then when the primary scab falls, which it normally does on the twenty-first day after vaccination, a sound surface to the previously diseased skin presents itself; but if the primary scab should be removed by a poultice or other means before the process of healing has

PLATE III.

Tenths and Hundredths of a Millimetre ×112.

sufficiently taken place, then a moist surface remains through which the humours of the body find exit, and drying, by reason of the warmth of the body, secondary sulphur scabs form in the place of vesiculation, and if these be removed by poultice an ulcerated place is found. This ulceration may extend a considerable depth, even right through the skin. This condition is more often seen when the vesicles have been subjected to maltreatment after vaccination with animal lymph than it is after like mistreatment with human lymph, although I have seen similar conditions after the use of either. The rule for treatment, therefore, is never to apply a poultice or wet or oiled rag until the normal areola has abated, which it normally does during the second week. If the primary scab has been removed either by maltreatment or otherwise, and the wound is covered by the secondary sulphur scabs, then a poultice may be applied to remove these—a warm bread-poultice is the best—and after this removal a piece of clean linen rag, on which is lightly spread some zinc ointment, may be applied to the wound. This should be changed every morning and night. Mercurial ointments should not be used: they almost invariably irritate the wound and thus prevent its healing. Let me also here caution you against the use of 'vaccination shields'; these might be proper if changed once a day, but otherwise they may become soiled with the discharges from the vesicle and are replaced with all their filth day by day; and, moreover, the uneducated class lend their shields to one another, and if not, put them by for a future occasion. What is more likely to produce septicæmia than the use of such articles? It is well to cover the part with a dry, clean linen rag, and to change it once or twice a day.

Now, the minute morbid anatomy of the skin when affected by small-pox is exactly as I have described it when vaccinated. You have the same stages of papulation, of vesiculation, and inflammation, and the same structures affected. (See Plate IV.) The small-pox vesicle is

generally umbilicated in the centre (see Plate IV., Fig. 1), and a hair follicle usually is present at the centre of this umbilication, as seen in Plate IV., Fig. 1. Some have been led to think that the hair follicle is the cause of the umbilication. There are several reasons, however, why we should hesitate to accept this explanation. First, because the umbilication takes place also in those parts of the skin which have no hair follicles, *e.g.*, the palms of the hands and soles of the feet. Secondly, because a vesicle never has more than a single umbilication, although covering an area having a plenitude of hair follicles. Thirdly, in inoculated small-pox it is the site of the initial inoculation which forms the umbilication, and if the inoculation be done in a line the umbilication of the inoculated vesicle forms in the centre of this elongated vesicle.

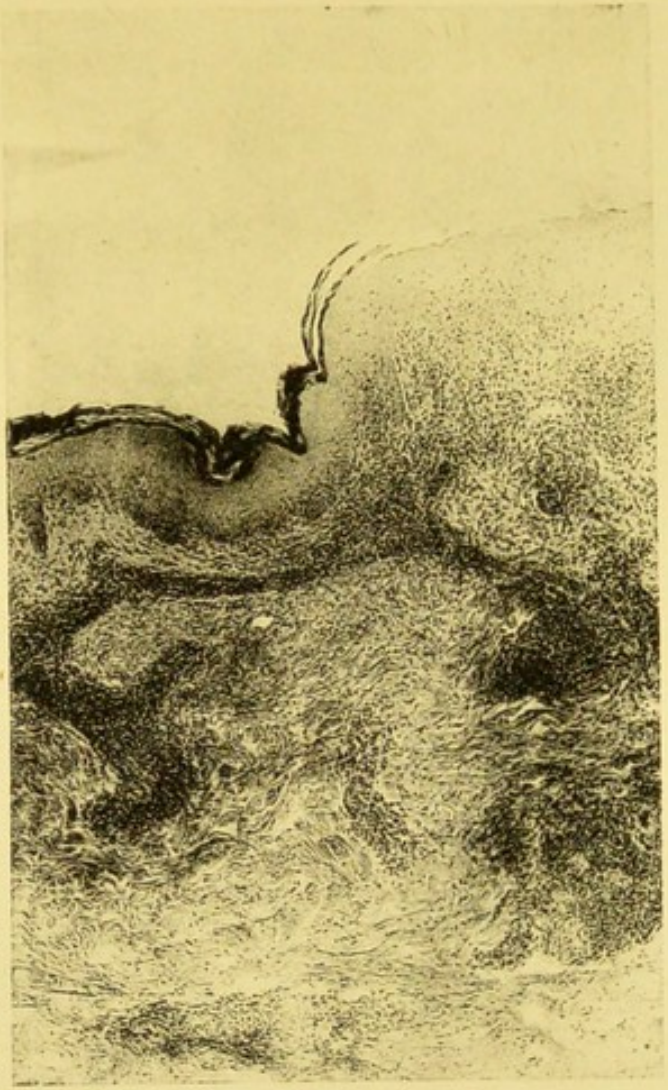
We are therefore led to think that the hair follicle really is not the cause of the umbilication. The reason probably will be found in the fact that the capillaries round the hair follicles are a little smaller than in other parts of the skin, and thus the germs of the disease are arrested in them more frequently. They thus form the centres from which the vesiculation takes place, and correspond with the centre from which the inoculated vesicle arises. This view will also help to explain why in small-pox you occasionally get more numerous vesicles over those parts where there is constant pressure before patients take to the incumbent position in bed. I have seen a distinct line of vesicles just below the knee on a woman. This was the part where she used to wear her garter. I have also seen the same condition on a man's shoulders, two strips of more closely placed vesicles where the pressure of the braces has been.

The microscopical appearance of the skin of the arm, due to the morbid condition set up by the development of a syphilitic chancre, is entirely different from that I have just described as due to vaccine. No vesiculation takes place either of the middle layer of the rete Malpighii, or, indeed, any vesiculation at all. There is a great prolifera-

Fig. 1.

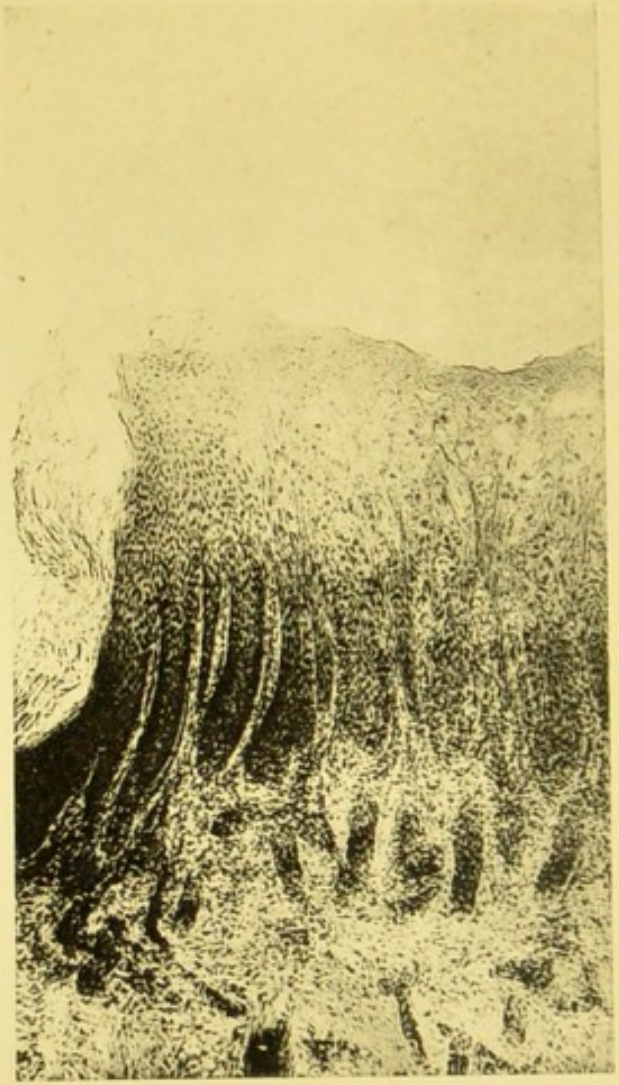
Small-pox vesicle from arm.

Fig. 2.



Chancre from arm.

Fig. 3.



Vaccine vesicle from finger.

PLATE IV.

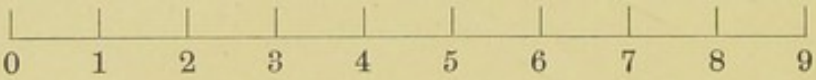
tion of small cells, which are best seen in the cutis vera and in the tissue immediately below this. These increase in number, extending upwards, and seem to crowd out the normal cells of the rete Malpighii until they reach the surface. The stratum corneum becoming detached from its normal bed, strips off, and you thus have left a secreting surface formed of the small round cells which have crowded out the normal cells of the rete Malpighii. From the micro-photograph (Fig. 2, Plate IV.) it may be judged how entirely different this morbid process is to that which occurs after vaccination. See Fig. 3, Plate IV. To borrow terms from botanical science, we might describe the syphilitic chancre as an endogenous, and the vaccine vesicle as an exogenous, growth. Hence we see the chancre and the vaccine vesicle have not even an anatomical relation. The only one they indeed have is linguistic, for one is called the small-pox and the other, in common parlance, is called the great-pox. If this be the association of thought, it recalls to our mind the doctrine of signatures of the last century. One example will suffice to explain this. The white meadow saxifrage (*Saxifraga granulata*), with its kidney-shaped leaves and their peculiar spotted surface, has a sort of likeness to the human lung; therefore the physicians of that day considered it a curative for lung diseases, according to the then prevailing doctrine that plants which represented in some sort of fashion various organs of the body were good for the disease of those organs they were supposed to resemble. This theory was called, therefore, 'the doctrine of signatures.'

LECTURE III.

THE DIFFERENCE BETWEEN A PRIMARY AND A SECONDARY VACCINATION.

We will now consider the difference between a primary vaccination and re-vaccination.

Let us consider a primary vaccination represented by a straight line. At one end of the line we will suppose that we are not as yet vaccinated, and this point we will mark as zero; at the other end of the line we will suppose that we are fully vaccinated, and this point we will mark 9. Let us now divide the line 0 to 9 into nine equal parts,



so that each division may represent the amount of modification the system undergoes during each day of vaccination.

We have performed the two following experiments, which we will detail here, as they will help us to understand the appearances of re-vaccinations.

The first experiment was: instead of putting all the vesicles on the arm at the time we first vaccinated it, we have put on only one; the next day we put on another, and so on until the tenth day, and in both cases which we had the opportunity of so vaccinating we found that the ninth day was the last day we could produce any specific effect from the vaccination. It was curious to observe

how the vesicles that were subsequently put on to the first developed. We will take that vesicle which was vaccinated four days after the first as an example. This vesicle arrived at its maturity five days after it had been inoculated, or on the ninth day from when the first had been inoculated. Moreover, it hurried through its stages, overtaking gradually the first vesicle, and both maturing together on the ninth day. That vesicle which was inoculated on the seventh day reached its maturity also on the ninth day from when the first vesicle was inoculated, or the second day from which it had been inoculated—in fact, all the vesicles matured on the ninth day from which the first had been inoculated. After the ninth day no further specific effect could be produced by inoculation of vaccinia.

M. Trousseau, on p. 121, vol. i., of his fourth edition of 'Clinique Médicale,' describes himself as having made similar experiments with the same results, and we know from Mr. Bryce as long ago as 1809 that this phenomenon had been observed, for on p. 173 of his book the following passage will be found: 'That if during the regular progress of cow-pox a second inoculation be performed a certain number of days after the first, the affection produced by this second inoculation will be accelerated in its progress so as to arrive at maturity, and again fade, at nearly the same time as the affection arising from the first inoculation, and that this will take place although the constitutional affection be so slight as otherwise to pass unnoticed.' In passing we may observe also that the same observation had been made with regard to the vesicle produced by the inoculation of small-pox — another piece of undesigned evidence of the close affinity of the two diseases. See p. 159, *et seq.*, 'Practical Observations on the Inoculation of Cow-pox,' by James Bryce, published in 1809.

The second experiment was: supernumerary fingers were vaccinated on the tip, and the finger removed on different days after vaccination.

For instance, one child was vaccinated on the tip of its finger, and the finger, together with the vaccine vesicle, was removed on the fourth day from the time it had been vaccinated.* About a month after the child was again vaccinated on the arm. The second vaccination ran rapidly through its course, reaching its maturity on the fifth day, and then began to decline. And it was further found in other children who had supernumerary fingers that, if the finger with the vaccine vesicle was removed on the second day after vaccination, then the subsequent vaccination performed a month after the stump had healed ran seven days' course. In the former case four and five make nine, and in the latter two and seven make nine. All the supernumerary fingers obeyed the same law, which was that, on the assumption the vesicle took nine days to mature, the sum of the times of the two vaccinations always equalled nine days. Let us look at the subject in a different light. We will suppose that during the growth of the vesicle a certain product is given off from it, and that when the system is saturated with this product, it is rendered incapable of further supporting the vesicle, therefore the disease terminates; but if we remove the vesicle before this saturation has taken place there remains something short of saturation, which condition is not incompatible with a further growth of the vesicle. Hence, if the vesicle should be removed at any time before its full development, there will remain in the system a capacity of a vesicle growing until saturation occurs. As we wish this idea to be fully realized, let us look at it from still a different point. We will suppose the vesicle to consist of nine definite concentric circles, one circle for each day's growth, and that each circle is inoculated by its interior adjacent circle. Now, if we remove the vesicle before its full development, then, *primâ facie*, there must remain so many circles to be completed before saturation occurs. In other words, by removal

* Paper by the author in the Transactions of the Epidemiological Society, vol. iv., p. 197, for the years 1875-81.

of the vesicle we prevent further auto-inoculation, and so all further diseased action ceases until we inoculate another portion of the skin. The vesicle will then proceed with its growth, not, indeed, from the beginning, but from the time it had been arrested, and so finish its growth.

Before going on with the immediate subject-matter of this chapter, we will consider another very remarkable fact, for it has its bearing upon what we are now considering. It is this: if we use lymph which has become inert by having been kept too long to produce a vaccine vesicle, yet we do produce a certain effect upon the individual we vaccinate with such lymph. This influence we can see if we again vaccinate successfully the individual, for the subsequent vaccination always runs a slightly accelerated course. The areola is thus very pronounced on the eighth day. Now, what reason can be given for this behaviour of the subsequent vaccination? This is the one we offer. Vaccine lymph may be considered to be composed of two parts—one the living organism, the other the product of the living organism which we assume to be the modifying agent.

When we, therefore, vaccinate an individual with lymph that has lost its vitality from age, we only introduce a small portion of the product that has been already formed. No fresh amount of product can be formed, as the organism which produces it is dead, and therefore no vesicle is formed, and only a very slight modification of the system is produced in the individual so vaccinated—a modification which declares itself in the slightly shortened course run by subsequent vaccination when a vesicle is produced. This consideration will point to a means of so vaccinating an individual that he may become after repeated inoculations with aged lymph insusceptible of further vaccination without his ever having had a vaccine vesicle; indeed, this seems to us a possible explanation of the only case of insusceptibility we have ever met with in over 61,000 cases. The child referred to was ten years old; its mother stated that vaccination had failed on previous occasions.

We failed twice running, but did not get the opportunity of trying a third time.*

Let us suppose that a person once efficiently vaccinated has proceeded from 0 on our imaginary line to 9; that there is a tendency to return, and that the retrograde journey may be quick or slow. We are acquainted with some of the conditions that influence the return journey, and we will name those we know at once, viz., the number of places a person is primarily vaccinated in.

In a considerable number of persons only vaccinated in one place, their return journey is quicker than if they had been vaccinated in four or more. We base our assertion upon the following evidence:

Mr. Marson, formerly the Medical Officer of the Inoculation and Small-pox Hospital at Highgate, published the following table, contained in a paper which he wrote as an article on small-pox published in the Medico-Chirurgical Society Transactions, vol. xxxvi.

Cases of small-pox, classified according to the vaccination-marks borne by each patient respectively.	Number of deaths per cent. in each class respectively.
1. Stated to have been vaccinated, but having no cicatrix	21¾
2. Having one vaccine cicatrix	7½
3. Having two vaccine cicatrices	4⅛
4. Having three vaccine cicatrices	1¾
5. Having four or more vaccine cicatrices ...	¾
Unvaccinated	35½

In compiling this table, Marson deducted the cases where a person not only died of small-pox, but also of some superadded disease; but he gives the number he so deducted, so for our purpose we may add these to his figures, and recast the percentages. This being done, we obtain the following number:

* Report of the Medical Officer of the Local Government Board for 1887, seventeenth annual report, p. 28.

	Cases.	Deaths.	Mortality per cent.
Unvaccinated	2,654	996	37·2
Stated to have been vaccinated, but having no cicatrix	290	74	25·5
Having one vaccine cicatrix	1,357	125	9·2
Having two vaccine cicatrices	888	53	5·9
Having three vaccine cicatrices ...	274	10	3·6
Having four or more vaccine cicatrices	268	3	1·1

Dr. Gayton, late Medical Superintendent of the Homerton Small-pox Hospital, has also published some 10,403 cases of small-pox, noting also the number of scars of primary vaccination on those who had been vaccinated. Subjoined are his figures. It is to be understood that Dr. Gayton, in compiling his table, threw out no cases of superadded diseases, so that Marson's table, as we have recast it, is strictly comparable with Gayton's:

	Cases.	Deaths.	Mortality per cent.
Unvaccinated	2,169	948	43·7
Stated to have been vaccinated, but having no cicatrix	1,295	352	27·1
Having one vaccine cicatrix	1,988	220	11·07
Having two vaccine cicatrices	2,225	178	8·04
Having three vaccine cicatrices ...	1,573	82	5·22
Having four or more vaccine cicatrices	1,153	37	3·2

In comparing these two tables, we at once notice that all the death percentages of Gayton's table are in excess of Marson's. For instance, Gayton's death-rate among his unvaccinated class is 43·7, while Marson's is 37·2. As far as this evidence goes, it shows that small-pox was more fatal among the unvaccinated in Gayton's time than it was in Marson's; that being so, it is remarkable that if we reduce the other percentages of Gayton by the fraction $\frac{37·2}{43·7}$ we arrive at results which are almost identical, and on such an inquiry the discrepancy is well within the

limits of what may be attributed to 'personal equation,' to borrow a phrase used in astronomical science.

In the next table we give Gayton's percentages so reduced and compared with Marson's:

	Marson's Mortality percentage.	Gayton's reduced by $\frac{37{\cdot}2}{43{\cdot}7}$.
Unvaccinated	37·2	
Stated to have been vaccinated, but having no cicatrix	25·5	23
Having one vaccine cicatrix	9·2	9·42
Having two vaccine cicatrices	5·9	6·9
Having three vaccine cicatrices ...	3·6	4·9
Having four or more vaccine cicatrices	1·1	1·9

We say this is a very close result of two different observers, and shows by undesigned coincidence how accurate both must have been in the collection and registration of such a mass of material.

That so great a difference should be observed in the percentage of mortality among the unvaccinated between the collection of Marson's and Gayton's statistics, seems to call for some comment. We do not think that there is any doubt that the fatality of small-pox has been increasing among the unprotected class since the commencement of this century, that is, from the commencement of vaccination. The death-rate among those having the natural disease at this time does not seem to have been greater, at most, than 22 per cent.; for out of 1,200 who took small-pox in Norwich in 1807, 203 died, *i.e.*, 16·9 per cent. Also in the village of Ware in 1722, 612 persons suffered from the small-pox, of which number 72 died; this gives a percentage of 11·7.*

Dr. J. Kirkpatrick,† in 1754, quoting Mr. Wall, of the Inoculation Hospital, says that, out of 1,415 small-pox

* See Dr. Monro's 'Observations on the Different Kinds of Small-pox,' vol. i. of the Royal Society's MS. Letters and Papers concerning Inoculation, p. 21.

† J. Kirkpatrick, 'The Analysis of Inoculation,' published in 1754, p. xxiv in the preface.

patients at that institution, 421 died, or 27·75 per cent., and adds, 'This is, indeed, an uncommon proportion,' and he gives some reasons to account for it.

Mr. Cross in the Norwich epidemic (before mentioned) found 46 who died out of 200 cases, and 50 who died out of 357, together being 17·24 per cent. From these examples —and they are not selected ones, but those we have met with—in all they amount to 3,784 cases, among whom there were 792, or 20·90. This we will take as the death percentage at the commencement of this century. The average time at which Marson collected his statistics was 1846, and he gives 37·2 as the percentage mortality of the disease at that time.

Dr. Gayton, in 1878, being the mean year during which he was collecting his cases, found the percentage mortality 43·7. Further, Dr. McCombie, in a paper entitled 'Comparison of Small-pox Statistic Epidemics, 1871 and 1876,' compiled from reports furnished by the medical superintendents of the various small-pox hospitals of the Metropolitan Asylums Board,* gives the mortality of the 1871 epidemic as 44·6 per cent., 3,649 cases, and 1,628 deaths; for 1876 epidemic as 45·5 per cent., 1,693 cases, and 771 deaths. Thus, we find the mortality at the commencement of the century 22 per cent.; in 1846, when Marson collected his statistics, 37·2 per cent.; in 1878, when Gayton collected his statistics, 43·7; in the epidemic of 1871 the mortality was 44·6; and in the epidemic of 1876 the mortality was 45·5. We are by this led to believe that there has been an increasing death-rate among the unprotected portion of the population. If this be true, of what value is the argument of those who say the diminished fatality of small-pox at the present time is due not to vaccination, but to the exhaustion, so to speak, of the disease, and that our present immunity from the plague, from typhus, and from leprosy, are analogous

* Transactions of the Epidemiological Society, vol. iv., 1875-81 p. 188.

instances? We have shown a reason for believing small-pox, instead of decreasing in fatality, has really doubled in virulence among a certain class, viz., the unvaccinated.

The reason for this increase of small-pox fatality among the unvaccinated population is, we believe, the following: When a disease has become endemic in a country for some centuries, and spreads among the population unchecked, we generally find the tendency is for the mortality from such a disease to decrease. Especially would this be the case with a disease like small-pox, which we have already shown to be a disease of childhood in unvaccinated communities. Almost everybody has the disease at some period of life, in the great bulk of people before they are twelve years old. Hence most individuals would have had their attack of small-pox before marriage, and chiefly those who had successfully combated the disease would be propagators of their race. We will take for granted the fact that physical properties are largely inherited, and therefore the children of those parents who had successfully combated the disease would be more likely to combat successfully with the same disease, *i.e.*, they would inherit a power more or less of resisting death from small-pox, and in this sense might be called stronger than those who would die. The population would, after some years, become gradually strengthened against death from small-pox, and the mortality of the disease would decrease.

Any method which would allow all to live and propagate their kind, such as vaccination, would remove this means of strengthening the population against small-pox, and hence those of the population who did not avail themselves of the method of safety would, after some years, feel the full brunt of the disease, and thus the fatality would gradually increase among them to such a degree as we know the mortality to be among a community which has never as yet had the disease, or not had it for some long time among them. We may instance how very fatal syphilis was when it first appeared in Europe,

and how fatal measles was among the Fijians in our own time (1875). It is true Dr. Corney attributes this mortality to the mistreatment of the disease by the natives. On page 84 of the Transactions of the Epidemiological Society, vol. iii., 1883-84, indeed, he mentions the reason we have given for the high mortality, but only to reject it. We may, therefore, be allowed to form our own opinion upon the matter.

Another factor which we know influences the return journey along our imaginary line is the character of the lymph used. As an illustration we will relate the following details: On December 15, 1875, we vaccinated a child, E. C., six months old, in four places. On the 22nd the child returned with two very small vesicles. The child had four more places inoculated on the 22nd, and when it returned on the 29th these were found to have all taken. Lymph was then taken from it and used for the vaccination of eight children in four places each. Of these the vaccination failed in four cases, one apparently took in three places, and two others in two places, producing small sores, with a light yellow scab. The one that was vaccinated in three places the mother refused to have done again, but the other two were re-vaccinated, one on January 12, 1876, and the other on March 8, and both took well in four places. This could not have been the case if the lymph had been taken at the proper time. From this case we may learn that lymph taken fourteen days after the first inoculation which is successful, though it be taken on the eighth day from the inoculation of the yielding vesicle —that such lymph, though capable of producing a local lesion on another individual, is, nevertheless, incapable of rendering the system immune from further vaccination.

Some apology to our readers seems called for for describing this last experience of ours. It must be remembered that the circumstances to which it relates occurred nearly seventeen years ago, before we had our present experience, and want at the time of knowledge must be our excuse.

In *Nature* of March 22, 1888, there is a short review of Dr. C. Creighton's book, 'Cow-pox and Vaccinal Syphilis,' and there we offer what we consider a very striking analogy which exists between vaccination and syphilis. We assume, however, a controversial matter, that of the original identity of the virus of the two kinds of venereal sores. For we believe that the virus producing the hard infecting sore is that inoculated at the time of its potency, whereas the virus which produces the local lesion only, or soft sore, is that inoculated at a time when the virus is old. In thinking rationally of this analogy, we might bear in mind the respective incubatory periods of the two diseases, syphilis and vaccinia, the latter being so much longer than the former, and consequently the much greater opportunities in the latter of getting a degenerate virus.

There is also another cause that influences the return march, which we can describe less definitely than the other two causes; but nevertheless it is quite as efficient, or even more so, to hurry or delay the return march. We will name this 'individual peculiarity.' As an example of what we mean, we will instance the liability of certain individuals to take small-pox twice in their lives. This, however, is very well known to be the exception of the ordinary experience, and we can at present only attribute this liability to some individual peculiarity, but of this we will speak more fully when on the subject of re-vaccination. There may be other causes which influence the return march which we know little or nothing about, but the three we have given will suffice for our purpose of illustration.

We will now suppose a person once vaccinated and to have arrived at the desirable point 9 of our imaginary line, and let us assume that every individual once vaccinated has a tendency to return to his original condition, represented by 0 on this line. We will further suppose that his return march is gradual, and that he has returned as far as the position marked 4 on the line. If such an individual were now re-vaccinated he would take up the disease at 4, and then

again complete his journey at 9. The re-vaccination would only run a five days' course. On this theory, the more rapid course a re-vaccination ran in an individual, the longer time that individual would have before he could contract small-pox. There are reasons for thinking that an individual would not be liable to contract natural small-pox until he had returned as far as the position marked 4. That is to say, if his re-vaccination took five days before the vesicles were at their height, then we may regard such an individual to have just arrived at the point in his return march at which he would take small-pox if exposed to it; that if he was between three and four he would have but a modified attack, and if beyond three on his return journey, then he would have small-pox as badly as if he had never been vaccinated.

What reasons have we for asserting this dogma? Marson, in his article on small-pox, published in vol. i., p. 477, of Reynolds' 'System of Medicine,' lays down the following law after the observation of many cases. He says the incubatory period of small-pox is twelve days, and that if a person be vaccinated during the first three days of the incubatory period of small-pox, such a person would escape the later disease entirely; but if a person's vaccination was delayed till between the third and fourth days of the incubatory period of small-pox, then he would have a modified attack of the disease, and if the vaccination was still further delayed beyond the fourth day of the incubatory period, then such an individual would have small-pox and vaccinia together, the one disease being uninfluenced by the other. We have seen several cases which have entirely corroborated Marson's law, so that we have every reason to believe it true. We will relate three cases, for they will illustrate not only our direct object, but also indirectly one of two others we wish to insist on.

Case I.—The following case is partially given on page 10, but it is now more fully related:

A woman's husband was taken ill with small-pox on

Wednesday, December 20, 1871. She had three unvaccinated children, two girls and a boy. These she took to Surrey Chapel on the following Tuesday, December 26, to be vaccinated. They were apparently vaccinated by Mr. Marson in six places, three being placed on each arm, in a position with regard to each other which was habitual with Mr. Marson. The names and ages of the children were: Herbert, aged six; Clara, aged four; and Laura, aged three months—the last having been born on September 24, 1871. The two girls became ill with small-pox on Sunday, December 31, *i.e.*, on the twelfth day after their father, and they were vaccinated on the seventh day of the incubatory period of small-pox. Clara died on January 8, 1872, of the disease, although her vaccination had taken as well as Laura's. Herbert escaped altogether. Laura we saw on January 16, 1895, at St. Thomas's Hospital. She was then severely scarred with small-pox, and had lost an eye from the disease. She, however, bore six good foveated scars of vaccination, such as we have seldom seen produced on a person who has previously suffered from small-pox. She affirmed that she was vaccinated before she had small-pox, but knew nothing further of her vaccination. She, however, gave me her mother's address, and, upon calling, her mother related the above particulars, except for the exact dates. These, however, we are able to supply from the register of the time, which was found to tally, as far as it went, precisely with the mother's story.

Case II.—A policeman brought three of his children to be vaccinated at Victoria Hall. They were aged respectively 11, 9, and 7 years. The eldest was a boy, the two others girls. These three children were vaccinated on May 26, 1881. Two of the children had been sleeping in the same room with their elder brother, and his eruption of small-pox first appeared on May 18.

Having paid some attention to the infective power of small-pox during its incubatory stage, we have come to the conclusion that small-pox is not infective to other persons

until this stage is over. The chances of two unvaccinated children sleeping in the same room as one with small-pox are greatly that they contract small-pox at the earliest date possible, and that will be, according to our experience, twelve days after the appearance of the disease in the first attacked. We should therefore look on May 30 as the day on which the eruption should appear in the two unvaccinated children, and this day really was the first day on which the two children manifested the disease. In the other, where the probability of infection was not so great—*i.e.*, in the child who was not sleeping in the same room, but who had access to her brother's—the child fell with the small-pox two days later. Thus we see in this man's family, consisting of himself and five children, only the man himself and his youngest child—both of whom had been vaccinated some time previous to exposure—escaped, while all the rest had small-pox. Three of these latter were vaccinated on the ninth day of the possible exposure, and these all had small-pox as badly as they could have it. The other, who was the eldest lad, and who had never been attempted to be vaccinated, also had the disease severely. We may add that we visited the cases, which were admitted to the Stockwell Small-pox Hospital, and they all presented the appearance of the unmodified form of the disease. The vaccination had taken in all three in every place, and the small-pox eruption was even more abundantly distributed within the area of that occupied by the vaccine vesicles, and for a short distance around. These cases, therefore, we may reasonably suppose were vaccinated on the ninth day of the incubatory period of small-pox, which was not modified thereby. We saw both the individuals who were vaccinated on May 26, 1881, one on June 15, 1895; the other on July 10, 1895. Both of them were pitted, and both had five indistinct scars of vaccination. Another case which we think worth recording, because the dates we can also accurately give; but the subject of this record had been previously vaccinated in infancy, and therefore the deduc-

tions to be drawn are not of so much value as in the former example.

Case III.—A gentleman, aged twenty-three years—a house-surgeon at St. Thomas's Hospital—in the beginning of the year 1871, which will be remembered as the greatest epidemic year of small-pox since the introduction of vaccination, saw and attended to a man who had been admitted with a fractured leg, and afterwards developed small-pox. The date on which he contracted small-pox was probably January 30, 1871. On February 1 he was vaccinated on the right arm, and on Wednesday, the 8th, he was taken ill with what proved to be small-pox, and admitted to the small-pox ward on the 9th. He had an abundant eruption, but this was not present on the right arm, or for an area round the vaccine vesicles. Here vaccination was presumably done between the third and fourth days of the incubatory period. The attack was a mild one, and this gentleman's face is not pitted or disfigured in any way. It is true that his previous vaccination in infancy must have had much to do with the modification of the disease, but the fact of there being no small-pox eruption on the right arm, and for a certain area round the vaccine vesicles, showed that the then present vaccination had some modifying effect, especially when we remember that in the first case reported the small-pox eruption was more abundant between the vaccine vesicles, and for some short distance in the area around them. From the observation of such cases as the three above related, Marson deduced his theory, and as the three cases which we have met with are entirely in accord with Marson's experience, we accept it.

LECTURE IV.

THE ERUPTIONS THAT OCCASIONALLY FOLLOW VACCINATION.

When we first began vaccinating we made it a rule to inquire into the history of all children who had eruptions following vaccination, especially those on whom the rash presented any appearance of syphilis. We know very well what the ordinary course of acquired syphilis is. Briefly to recall the chief points important for our present purpose, they are: first, a period of incubation of about three to five weeks, and this rule holds on whatever part of the skin the individual may inoculate him or herself; second, there is another interval of time between the development of the chancre and the appearance of the rash. This second interval is usually about two to four weeks more; so that it would be five to nine weeks from the inoculation of syphilis until we saw the secondary rash upon the body. The ordinary course of hereditary syphilis is for the appearance of the rash to follow after the same interval that occurs in the acquired disease between the development of the chancre and the appearance of the secondary rash, the interval between the inoculation and the development of the chancre being annihilated. Now, eruptions which follow vaccination, even if of a syphilitic nature, nearly always appear about the tenth day after vaccination, and it follows, that if this appearance of a syphilitic rash on the tenth day is due to the inoculation of syphilis at the time of vaccination, the disease in such cases persistently follows a very unusual

course. This unusual course is not to be noticed in the twenty-six cases or so which Mr. Hutchinson* has published of syphilitic inoculation after vaccination, and in one case which we saw the disease followed its usual course unmodified by vaccination. For instance, it took twenty-one days from the vaccination to the first appearance of the chancre, and thirty-six days from the first appearance of the chancre to the appearance of the secondary rash—fifty-seven days in all, or one day more than eight weeks. Hence we may fairly assume that when syphilis is inoculated at the time of vaccination it will follow its usual course. The explanation why the eruption appears so frequently on the tenth day of vaccination is, we think, because the child so affected is suffering already from hereditary syphilis, and the skin irritation occasioned by the vaccination simply determines the time of the appearance of the rash. Vaccination, there is no doubt, is a cutaneous irritant, much less so, however, than small-pox. With the former it is only the weak skins, or those suffering from some idiosyncrasy, that suffer. In the latter the irritation is so strong that all skins break down, and that in a definite manner, and the rash is therefore characteristic of the disease.

The rashes which follow vaccination, however, are not definite—in fact, are as numerous in character as there are rashes to which children are liable; they are determined more by the nature of the child's organism in whom they occur than by the vaccinia. It is thus we explain the very various forms of eruption which are met with after vaccination: it may be a general erythema, or an eczema, or an urticuria, or a lichen, or may partake of the appearance of any other rash to which children are liable. Measles, scarlet fever, and small-pox have each of them their own special character of rash, so that, from seeing them, it is possible to say to which of these diseases they are to be referred. With vaccinia this is impossible, the appearance of the rash, if it exist at all, being so indefinite. It is well

* 'Illustrations of Clinical Surgery,' 1875.

PLATE V.

Fig. 1.

Fig. 2.

West, Newman chromo.

known that certain local irritations are sufficient to cause lesions in weak skins. Thus, the wet napkin will cause intertrigo; a common head cold will cause sores about the orifice of the nose; the saliva will cause the angles of the mouth to be cracked, sore, and tender; and the perspiration from the head will cause impetiginous sores behind the ear, etc. On skins on which these local conditions are sufficiently potential to cause mischief, vaccination will also be potential to do the same, and the vaccine vesicle will be ill-developed or abnormal in appearance, and cannot be expected to confer the most lasting immunity from small-pox that vaccination is capable of affording. For a common appearance of the vaccine vesicle under the above abnormal conditions see Plate IX., Lecture V., p. 70. Fig. 1, Plate V., was taken from a child whose father contracted syphilis shortly before his marriage. It was the second child of the marriage; the first died within a very short period of birth. This child, being apparently healthy, was vaccinated at St. Thomas's Hospital in 1878. It was duly inspected, and was brought again with the eruption represented, which first appeared on the tenth day after vaccination. This is a very good example of the cases of alleged syphilis after vaccination. It is so tempting for parents to lay the results of their own iniquities upon vaccination, especially when they are encouraged so to do by shameless agitators. To enable us to view the truth of these allegations against vaccination, we will suppose a man to have had syphilis and to play a game of football: he receives a kick on the shin, and in due course a syphilitic node may develop from the bruise. The man would be as entitled to say he acquired his syphilis from playing football as a parent of a child who has had syphilis would be to say that the child acquired its syphilis from vaccination.

There is one more most striking fact which receives an easy explanation from the above view, and would be otherwise quite incomprehensible without it. We allude to syphilitic eruptions following the use of calf lymph, and

that about in the same proportion as after the use of human lymph. It may be accepted without doubt that calf lymph which has never passed through the human being since its origin is perfectly free from the syphilitic taint, and yet syphilitic eruptions follow its use. This fact alone should, in this particular of syphilitic infection, restore our confidence in the use of human lymph.

Another eruption to which children are subject after vaccination is urticaria. It is well known that adults who are liable to urticaria may have it readily excited by slight causes. Thus, a scratch is often sufficient, or a meal of shell-fish, especially crabs or mussels. Oatmeal will provoke it in others; strawberries in others, etc. Plate V., Fig. 2, represents a severe form of the eruption as it occurred in a child, A. R. T., in 1879. Plate VI., Fig. 1, also represents the right flank of the same child, and Plate VI., Fig. 2, represents some of the spots about the natural size, with the details filled in. The child was vaccinated on November 4, at Surrey Chapel, from human lymph. The rash first appeared on November 13; the drawing was taken on November 19. On the sides of the cheeks, on the dorsum of the feet and the backs of the hands, the eruption became vesicular or even bulbous; but not so on other parts of the body. This severe form of the rash follows vaccination in about 1 in 10,000 cases. It is as common after calf lymph as after human lymph, and the inoculation of another child with the serum from the vesicles produces no result, having first ascertained its harmlessness by self-inoculation. The eruption again appeared two or three months later during dentition. Plate VII. represents an urticaria, the drawing being taken at a late stage of the eruption.

Another eruption which happens after vaccination is eczema, chiefly occurring about the head and face, or as intertrigo about the buttocks, axilla, or in the folds of the neck. Impetigo behind the ears is also met with, and tinea tarsi; but these evils are often excited by local

PLATE VI.

Fig. 2

West, Newman chromo

PLATE VII.

West, Newman chromo.

PLATE VIII.

West, Newman chromo.

irritations, as we have already said, before vaccination, and only when they occur after vaccination can vaccination be truthfully accused of being an exciting cause.

Lichen in its various forms may also follow vaccination, but lichen also occurs during dentition in some children. See Plate VIII., which illustrates this in a severe form; this rash came out on the tenth day after vaccination from calf lymph.* When lichen occurs during dentition, this, we think, must be caused by some abnormal process of digestion; the irritation of the mouth reaches the stomach, thus giving rise to the abnormal process. The abnormal products are absorbed, and these, circulating in the blood, irritate the skin and occasion the eruption which at such time often appears. Mothers, as a rule, are quite aware that their infants may suffer from eruptions of various kinds during dentition, and they are content when they say that the child has a gum rash. They then rightly never think of attributing it to the impurity of the tooth that the child has just cut, but if the eruption happens to follow vaccination the hated rite gets the blame.

We have once seen purpura follow vaccination in the same way as purpura may be an early symptom of small-pox. Hæmorrhage into the vesicles we have also seen in one child who was suffering from whooping-cough. Hæmorrhage in this case was no doubt due to the congestion of the skin caused during the paroxysms of the cough.

Mr. Hutchinson, on December 9, 1879 (*British Medical Journal*, p. 960, December 13, 1879), exhibited the body of a child (at the Medico-Chirurgical Society) which had been vaccinated on November 11. An eruption had come out by the eighth day, which the medical man under whose care it was believed to be variola. Three days later the vesicles of the eruption were surrounded by large red areolæ, which became circular gangrenous patches. The skin where the eruption had been was, at the time the

* The artist has not been happy in the representation of the body form, but the eruption is faithfully represented.

body was exhibited, as if it had had a hole punched out, so abrupt were the margins of the wounds. Another case of this complication after vaccination is published in the Dublin *Journal of Medical Science* for June, 1880, by Mr. William Stokes.

The child in question was vaccinated on February 7, 1880. On the morning of the 9th a number of purple and black spots appeared first on the buttocks, next on the face, and subsequently all over the body. The sloughs appeared, as in Mr. Hutchinson's case, over the sites of the eruption. There were three well-marked vaccine vesicles on the arm, which appeared healthy.

In Guy's Hospital museum there are two wax models of what is called varicella gangrenosa. These exactly resemble the gangrenous patches in Mr. Hutchinson's case, and we think the same conditions of system were present in all those children who so suffered—two after vaccination and two after chicken-pox—and we are inclined to believe that disseminated tubercle was the real cause of them.

Auto-vaccination is occasionally seen. We have seen it in children who had intertrigo in the groin, and who, after scratching their vaccinated arms, had transferred their hand to their groins, thus producing a crop of vesicles on this part. We have also seen vaccine vesicles on the face from the same cause, and we have twice seen a general eruption of vaccine vesicles on the body in children who had been vaccinated. In both these cases the children were in public institutions, and had been thoroughly washed every morning by a nurse of the institution. As tow is very properly used in general instead of a sponge, and the vaccinated arm had taken part in the ablution, the tow, having been wiped over the rest of the skin, had caused a general inoculation of the surface. This seems to be more frequent in France than in England, and the French have given it the name of vaccina généralisée; but that it is due to wholesale auto-vaccination we have little doubt.

LECTURE V.

THE PRACTICAL DETAILS OF VACCINATION.

We shall first speak of the lymph which it is best to use, and how it should be used.

It is always best to use perfectly fresh lymph, and to vaccinate directly from arm to arm or from calf to arm.* The lymph used from child to child should be taken not later than the eighth day, *i.e.*, on the day week. The child which is to be the vaccinifer is vaccinated, say, on Tuesday, and the following Tuesday the lymph should be taken. The lymph should not be taken later than on this day, for if it be, it has a great tendency to produce unduly inflamed arms on the children vaccinated, or to produce abortive vesicles, called by the first vaccinators spurious vesicles. These vesicles may not be protective against further vaccination, and certainly do not give that lasting protection against small-pox that properly performed vaccination is capable of giving. The lymph may be taken earlier without the chance of these untoward results, but it is difficult to obtain any quantity on the earlier days. Further, the lymph taken after the day week is seldom effective after a week's storing.

Lymph from a re-vaccination should in no case be used; nor should lymph from a much-inflamed arm, or lymph that is thin or serous. Thick lymph, which at first oozes

* In saying this, gentlemen, I should tell you, however, that, although such has been the policy of the Local Government Board up to the present time, there is the probability that this policy before long will be altered, when different instructions will have to be given.

from the vesicle when it is pricked, should be used. No child that is unhealthy or has any skin eruption should be used as a vaccinifer, and in all cases care should be taken to examine the buttocks of any child from whose arm the lymph is taken to vaccinate another. This last precaution is very necessary, for we are able to eliminate all cases of dangerous children. Syphilitic children during the latent or incubatory period of the disease are not infective, but become so immediately the symptoms declare themselves. It has been thought that if the lymph was used unmixed with blood then there was no chance of conveying syphilis; but this is an error. The proper precaution to take is to note if there be any symptoms of the disease present in the vaccinifer, and to reject all suspicious children. The lymph from an apparently healthy child is perfectly safe, although it may be incubating the disease. Eczema in children is a skin disease which frequently causes the vesicles to be ill-formed and sloughy-looking, of which Plate IX. represents a case. Of course lymph should never be taken from an abnormal vesicle to vaccinate others. Lymph which is carelessly selected has a great tendency to become weak, *i.e.*, it produces persistently what are called advanced arms, that is, an arm where the areola is formed on the seventh day instead of the eighth, and is consequently very well marked on the eighth day, when it should only be forming. Some practitioners consider the eighth too early for the areola to be present, but we are sure this is a mistake. We always like to see a little areola on the eighth day. If there is none, the child is often out of health, or has possibly been taking mercury in some form, usually as gray powder. We have noticed this to be the case over and over again, viz., that mercury has the power of delaying the appearance of the areola. We have also given mercury in healthy infants for a week before vaccination, and continued the drug during vaccination, with the same result. Plate X. shows a typically good arm, from which lymph might be taken.

PLATE IX.

West, Newman chromo.

PLATE X.

West, Newman chromo.

The vesicles should be pricked towards the margins with an ordinary sharp bleeding lancet, the flat of the instrument being held parallel to the surface of the skin (Plate XI.). In this way blood is usually avoided. It would be otherwise if the lancet were held perpendicularly. The vesicle should be pricked all round the margin, for, as we have before stated, the lymph is contained in a sort of honeycombed structure, and therefore requires a good many punctures for its liberation (Plate II., p. 43).

If the vesicles be shallow, they are very difficult to prick without drawing blood, and if this should happen, care must be taken not to mix the blood with the lymph, for if this be done the lymph should not be used. It is best to wait a minute or two before we endeavour to take lymph either on the lancet or in tubes or points, and having waited, it will be found that the blood has coagulated, and may then be removed on the point of the lancet without mixing with the rest of the lymph.

The next step is to attend to the child that has to be vaccinated. The left arm is the one usually selected, and it is the one most convenient for the vaccinator. The arm should be taken out of the sleeve, and held in the left hand of the vaccinator, between his fingers and thumb. This gives him a firm hold of the child's arm, and he is not so likely to be interrupted by a hysterical mother during the performance of the act. It also enables him to blanch the skin of the arm where he is about to vaccinate by drawing it tight between his fingers and thumb, and thus preventing bleeding taking place during the act; and, lastly, it drags the incisions apart, and allows the lymph to touch the fresh-cut surface. The lancet should be blunt, and the incision made obliquely. The blunt lancet is preferred because it tears rather than cuts the capillaries, and a torn vesicle, as every surgeon knows, bleeds less than a cut one. The incision is made obliquely, because the portion of the skin that the first changes occur in, as has before been stated, is the middle layer of the rete Malpighii, and an

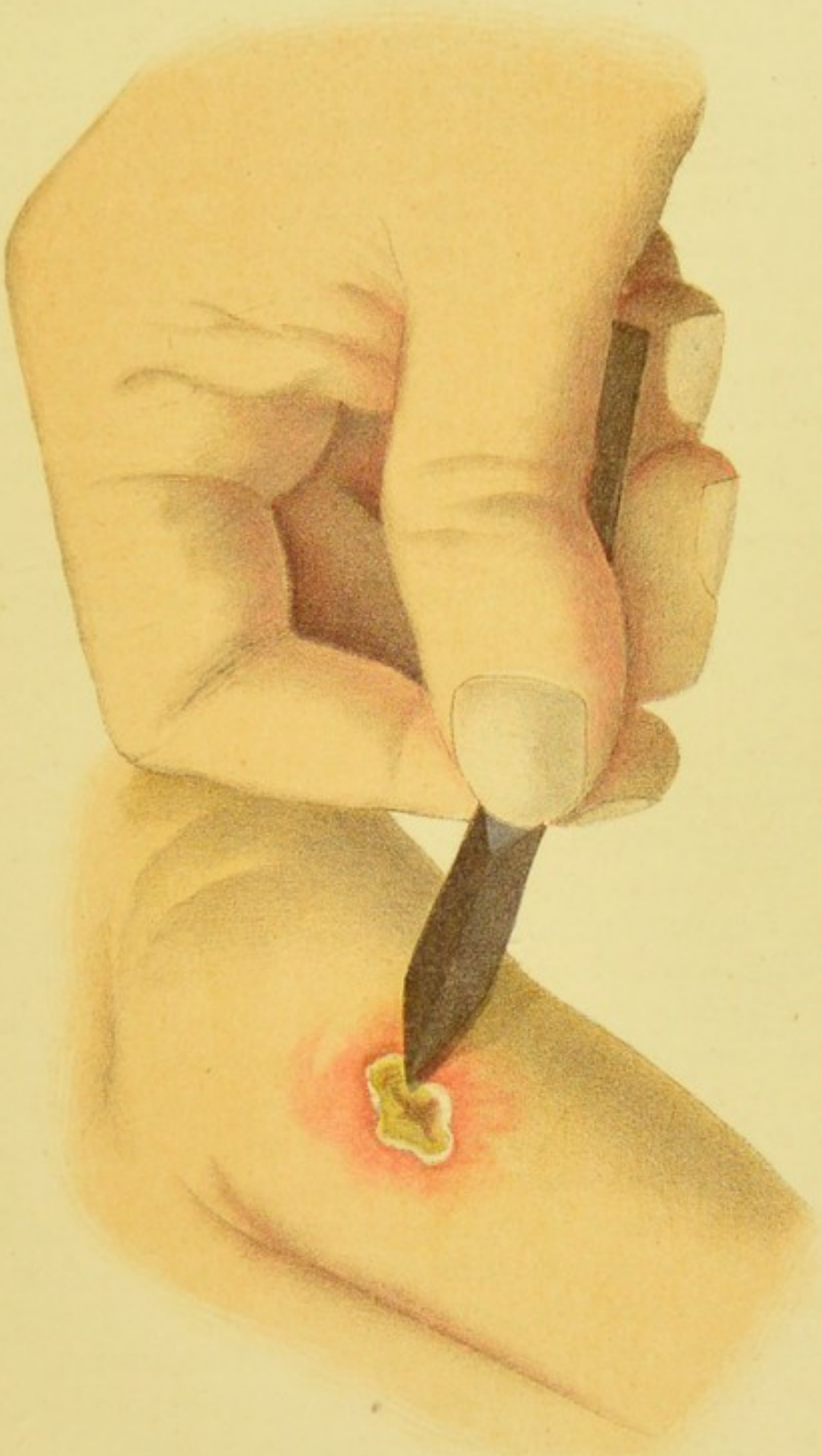
oblique incision exposes a larger area of this than a perpendicular one. An oblique incision also causes less bleeding than a perpendicular one. The lancet used for vaccination should never be used for any other purpose. It should be dipped in water after each vaccination, and wiped upon a clean towel. It is also a good plan to heat it in a spirit-lamp before commencing the day's vaccination and chilling it in water. This method does not improve the appearance of the lancet, but it is a very effective means of disinfecting the instrument. The lymph is taken from the vaccinifer on one side of the lancet, and should cover its tip; the side of the instrument which is free from lymph should be the side next the skin while cutting; the blade of the lancet should be turned on the handle, so that it is at right angles with it, and the upper part of the blade is to be held between the thumb and middle finger, with the forefinger on the angle made by the blade and handle. The little and ring-fingers should rest on the arm to be vaccinated, and the cuts made upwards, and the lymph placed on the cuts and gently pressed in with the flat of the instrument. When well-selected lymph is used, and after very little practice, it will be found that at least 94 per cent. of the insertions of the lymph are successful. Our own insertion success with humanized lymph, directly from arm to arm, for the last twenty-two years at St. Thomas's Hospital and Surrey Chapel was 96·18 per cent., there being 9,011 cases.

It will be convenient here to refer to the so-called insusceptibility of individuals to vaccination, and we cannot do better than quote a note of the late Medical Officer of the Local Government Board, Sir George Buchanan. It is as follows:

'The following passage (from Medical Officer's 1887 Report) contains the experience of Dr. Cory, as to what is called 'insusceptibility' of children to vaccination:

'"In accordance with your wish that I should record my experience of vaccinating children who have been certified

PLATE XI.



West, Newman chromo

as 'insusceptible,' I have to inform you that at various times four such cases have been sent to me at Surrey Chapel, and five to Lamb's Conduit Street, and that in every such case my first attempt at vaccination has succeeded. The resulting vesicles (whether done with human or with calf lymph) have been quite characteristic of vaccine, but eight of them were accelerated in their course in the same way that I have observed after a first unsuccessful operation by myself.

'"Of my own vaccinations, I may say that I have in my time performed over 38,000 primary operations with human or with calf lymph, and that it has only once fallen to my lot to fail twice at an attempt at vaccination. The subject in this instance was a ten-year-old child, in whom, as stated by its mother, vaccination had been attempted on previous occasions without result. My operation failed at the second attempt, and I did not get the opportunity of trying a third time.

'"I believe the late Dr. Marson has recorded an identical experience from several thousands of operations performed at Blackfriars Station, where humanized lymph only was used."*

'Dr. Cory has since furnished the Medical Department with further details as to his failures, complete and partial. They are all based upon experience of primary vaccinations with unstored lymph, each operation being performed by five superficial scratches.

'Among some 16,000 first attempts at vaccination with humanized lymph, he has had fourteen failures, being at the rate of one failure in 1,140 children operated on.

'Of 22,041 first attempts at vaccination with calf lymph, he sets aside 44 cases vaccinated (successfully) for the cure of nævi, and 216 others that did not return for inspection.

* 'I may properly point out that Dr. Cory does not here claim for himself any exceptional skill above his fellows. Reporting on his insertion success at the Animal Vaccine Station, again he tells of one of his colleagues getting results like his own, but a trifle better, during consecutive years.'

Among the 21,781 vaccinated on their arms with calf lymph, he has experienced 70 failures at a first attempt, being at the rate of one failure in 311 children operated on.

'The vaccinations of this latter class—those from the calf—were therefore distinctly more difficult than those done from arm to arm. It is to this more difficult class that the following figures relate :

Five insertions succeeded in			19,925	instances.
Four	,,	,,	1,011	,,
Three	,,	,,	407	,,
Two	,,	,,	224	,,
One	,,	,,	144	,,
All insertions failed in			70	,,

'It would appear from the above and other similar considerations that total failure in primary vaccination is explicable without recourse to any hypothesis but that which suffices to explain partial failure; and this cannot, by the nature of the case, be an "insusceptibility" in the true sense of the word.

'Nevertheless, there is a so-called "insusceptibility," with which, for practical purposes, vaccinators are concerned, namely, failure to obtain any vaccine vesicle in a given child after three several attempts at vaccination. This failure constitutes a *statutory* "insusceptibility," and it is desired to estimate in the present note how frequently a "certificate of insusceptibility," in this sense, is to be expected from one and another class of operator.

'It has to be premised that a second attempt at vaccination of the same child is not quite so likely to succeed as a first attempt, and a third attempt is not quite so likely to succeed as a second. If it were not for this consideration, the probability of failure after three attempts would be once out of x^3 cases, where x = the number of cases yielding one failure at a first attempt. But with allowance for the differing probability of success at repeated attempts to vaccinate, we must expect a failure at a third attempt to occur more often than once out of x^3 cases. If we can

learn how much more often, we shall be able to foretell the probability of failure at a third attempt in the practice of any vaccinator for whom the quantity x is known.

'There are certain American experiences* which go to show the probability of failure at a third attempt to be once out of two-ninths of x^3; and there are some German experiences† which would place it at once out of one-ninth of x^3. There are no English experiences available for such an estimate.

'Let us first use the assumption, derived from American experiences, that the probability of failure at a third attempt is once out of two-ninths of x^3.

'Now, on the scale of success attained by Dr. Cory when vaccinating with calf lymph, $x = 311$, and $2x^3 \div 9 = 6{,}684{,}495$, and this would be the number of children who would be expected to furnish one child "insusceptible" in the statutory sense of the word. With humanized lymph, in Dr. Cory's practice, the number $x = 1{,}140$, and $2x^3 \div 9 = 329{,}232{,}000$, this being the number of children who would be expected to furnish one child "insusceptible" in a statutory sense.

'Or, on a lesser scale of success (one that a practitioner, when vaccinating from arm to arm, may reasonably look to attain)—say not more than one failure per 100 children submitted to operation, we should have $x = 100$, or $2x^3 \div 9 = 222{,}222$, as the number of children who would be expected to furnish one "insusceptible" child among them.

'Or, if a vaccinator's scale of success were so unsatisfactory that out of 20 attempted vaccinations he habitually experienced one failure at the first attempt, it would be expected that a "certificate of insusceptibility" might be given as often as once for every 1,778 children presented to him for vaccination; but such a 5 per cent. of first failure

* Fifth and Sixth Reports of the Board of Health for New York, p. 120.

† Uebersicht der Ergebnisse des Impfgeschäftes im Deutschen Reiche für 1882, pp. 8, 9, 16, 17, 24, 25, in the Report of the German Vaccination Commission of 1884.

is only to be witnessed in the practice of those who vaccinate unskilfully, or to an undue extent with preserved lymph. A scale of failure amounting to once in every ten first attempts cannot but be regarded as inexcusable; on that scale, the frequency of certificates of "insusceptibility" would be once in 222 cases submitted to vaccination.

'From the above calculations, based on the assumption derived from American experience, let us pass to examine the question on the basis of the German experience, according to which the probability of failure at a third attempt is once out of one-ninth of x^3; and this would be the number to give one instance of what is here called "statutory insusceptibility."

'Then, on Dr. Cory's scale of success, he would not have more than one "insusceptible" out of every 3,342,247 children whom he vaccinated with calf lymph, or more than one out of every 164,616,000 children whom he vaccinated with human lymph. On the next scale of success, a practitioner, having at his first attempt one per cent. of failure, might expect one "insusceptible" case out of 111,111 primary vaccinations. And on the unsatisfactory scale above considered, where there were no less than five per cent. of failures at the first attempt, a vaccinator would be expected to certify one case as "insusceptible" out of 889 children submitted to him; while on the extravagant scale of one failure out of every ten first attempts the statutory "certificate of insusceptibility" would be given once out of 111 operations.'

Lymph is preserved in two ways at the present time in England. Firstly, in capillary glass tubes, and secondly, on ivory points. We will consider first how the lymph is introduced into the glass tubes. The vaccine vesicles are pricked in about twenty places towards their margins, and after waiting a minute or two the lymph oozes out and collects in small drops on the vesicle. One end of the tube is applied to the drop, and it enters by capillary attraction. If the tube be held perpendicularly the force of capillary attraction will only cause it to enter about one inch in a

tube of average bore, but if the tube be held downwards so as to allow the force of gravity to act advantageously, the tube may be filled. Two-thirds of the tube, however, should only be filled, and when this amount has entered, *but not before*, it should be shaken down in the same way as an index of a thermometer, by striking the hand in which the tube is held against the other. If the lymph is shaken down before all has entered, the column of lymph will be broken up by intervening air. Having got the lymph in the tube and shaken it down, you next proceed to seal the ends; this is best done by the aid of a spirit lamp. The tube is held by the finger and thumb as far towards the end as there is any lymph, so that the lymph in the tube is prevented from being heated. First seal the wet end—that is, the end by which the lymph entered; keep the glass tube red-hot at the immediate end without melting it, so that the tube is not closed until the carbon which results from the charring of the lymph has been burned off the immediate end. If the glass be melted before this has taken place the sides of the tube approach without coalescing, coalescence being prevented by the layer of charcoal, and it is then quite impossible to burn the charcoal off because the air cannot gain access to it. Having closed the wetted end of the tube, proceed to close the other, and to do this turn the other end of the tube towards the flame, at the same time slipping your fingers and thumb towards the end to be sealed, so as to protect the lymph from the flame as you did the first end. Then quickly pass the empty portion of the tube through the flame, and seal immediately. This you will have no difficulty in doing, for there will be no charring of the lymph, this being the dry end. It will now be evident why the wet end is sealed first, for if we drew this wet end through the flame the whole length of the empty part of this end would be blackened.

It will be a useful preliminary practice to try a few experiments with tubes. Thus, first take a tube and seal one end, then dip it in the ink-bottle—only a very small

quantity of ink can enter, for if the ink entered, the air inside the tube would be compressed. Now, as capillary attraction is a force by which, if the other end of the tube was open, the ink would enter, and as the compressed air would be a force in the opposite direction to force the ink out, the ink would arrive at a state of rest as soon as the two forces in opposite directions balanced one another; but as the force of capillary attraction is a weak one, it is only able to compress the air in the tube to a very small extent, therefore the ink only enters for a very short distance. Now pass the tube through the flame of a spirit lamp, and rapidly dip the open end again into the ink. As the tube cools the ink will rise, for by drawing the tube through the flame you have expanded the air, and you can see how much air has been expelled by noticing how far the ink has entered. If you are quick, you will find that about half of the air in the tube has been expelled.

Now take another tube, seal one end and allow it to cool, then seal the other end without drawing any portion of the tube through the flame; the probability will be that a little glass bubble is produced at the end of the tube. These two little experiments will show you the rationale of the processes just advised for the sealing of tubes. There is one more little manœuvre that is useful to know. Lymph often coagulates in the tubes, and when you have broken both ends off you will often find it impossible to blow it out of the tube, but this misfortune may always be avoided. Notice which end of the tube the lymph has entered, and before you have broken off either end, pass this end through the flame of a match, being careful not to pass any of the column of lymph through, for a comparatively low temperature renders the lymph inert. The steam and expansion of the air caused by the heat of the flames will force the lymph towards the opposite end, and thus loosen the lymph in the tube. You can now break off the ends of the tube, and the lymph will be easily blown out.

About ten tubes may be charged from the arm of a child vaccinated in five places, and not more. There is often a

temptation to take more lymph from what is called a good yielding arm, but the lymph, after filling ten tubes or so, although it looks clear in the tubes, is not so active as that which at first flows, and will not produce such successful results on other children it may be used for.

Lymph preserved in tubes should always be kept in a cool place away from the light. It has been ascertained that two years is about the maximum length of time that it will keep active. It loses its activity gradually, so that the insertion success becomes less and less as the age of the lymph increases. We submit the following table, which gives our experience during the period 1889 to August, 1893, at St. Thomas's Hospital and Surrey Chapel with humanized lymph as used only by ourselves for primary vaccination.

TABLE I.

COMBINED SUCCESS OF HUMANIZED TUBE AND POINT LYMPH USED AT ST. THOMAS'S HOSPITAL AND SURREY CHAPEL DURING THE PERIOD 1889 TO JUNE 30, 1893, BY OURSELVES FOR THE PURPOSES OF PRIMARY VACCINATION ONLY. TUBES 89 CASES, POINTS 27 CASES.

Children, Tube Lymph.

Different periods kept.	Cases.	Insertions.	Successful.	Per cent.
Under 10 days	17	85	57	67·06
10 days to 20 days	9	45	25	55·55
20 ,, 50 ,,	9	45	29	64·44
50 ,, 100 ,,	37	185	130	70·27
100 ,, 150 ,,	6	30	22	73·33
150 ,, 365 ,,	11	55	20	36·36
2 days to 365 days	89	445	283	65·39

Children, Point Lymph.

Under 10 days	16	80	70	87·5
10 days to 20 days	5	25	14	56·0
20 ,, 50 ,,	6	30	16	53·3
50 ,, 100 ,,				
2 days to 44 days	27	135	100	74·4

With regard to preserving and using lymph on points, in pricking the vesicles to take lymph, the same precautions are necessary as for tube lymph, saving that, if blood be drawn from any vesicle, this should be absolutely rejected, for it is impossible to examine microscopically the lymph taken on points for blood discs. Especial care is likewise incumbent upon the medical man to see that the vaccinifer is free from all syphilitic symptoms, and that the vesicle he takes lymph from is quite normal in appearance. Having pricked the vesicle in several places towards the margin, the lymph soon oozes from it, and it is taken up on the tip of the point on both sides, care being taken not to squeeze the vesicle, but only to take that lymph which has come out. A good yielding arm which has been vaccinated in five places should serve to charge about forty to fifty points. It should be known, however, that the first lymph which flows is the most active. A vesicle which continues to run with lymph is by no means to be exhausted, as the last lymph which flows is only the serum of the blood, and it is not to be depended upon to produce good results on the children that may be vaccinated with it.

The points as they are taken should be laid on a piece of glass with ground edges, for this can be washed after it has been used each time, and thus you can avoid the soiling of the points. Keep them free from foreign contamination. If they are placed upon wood, or a book, it often occurs that they stick when dry owing to a wet portion of the point having inadvertently been laid upon them, and when it is separated a portion of dirt is pulled off the wood or book and adheres to the point. The points are usually made from ivory, but there is no reason why other substances should not be used. It has often struck us that white vulcanite or celluloid might advantageously be used. To use the points, one point should be used for each insertion of lymph. The point should be dipped into cold water. All the superfluous water should then be thrown off, and the moistened points laid on a piece of glass. This

should be done before proceeding to vaccinate with them. Next have the individual's arm whom you are about to vaccinate got ready. Let the arm be taken out of the sleeve as before described on page 71. Hold it in the same manner and make your scarification. Then, without letting the arm loose from the left hand, proceed to rub the lymph off the moistened point over one of the scarifications, and so with the rest, using a fresh point for each scarification. It is best not to use the points a second time unless you take the trouble of boiling them in water for fifteen minutes, which may be conveniently done in a test-tube, or in a kettle, taking care that the water boils the whole time. They should then be dried between folds of clean blotting-paper and put by in a clean stoppered bottle for future use. They should on no account be put in the waistcoat pocket.

The maximum length of time the points will keep active is about three months, but they lose their activity with age, so that the point of twenty days is less active than that of two days. The following table shows our experience of them as kept.

TABLE II.—ANIMAL LYMPH.

RESULTS OF VACCINATION OF CHILDREN WITH CALF LYMPH PRESERVED ON POINTS AND IN TUBES FOR VARIOUS PERIODS.

Mode of storage.	Time during which lymph was stored.	Aggregate number of insertions made (5 to each child).	Aggregate number of successful insertions.	Percentage of insertion success.
Points	Under 10 days	40	34	85
	10-20 days	25	21	84
	20-50 days	70	63	90
	50-100 days	70	51	73
	100-154 days	60	29	48
	Over 154 days	30	0	0
Tubes	Under 10 days	75	65	87
	10-20 days	25	17	68
	20-50 days	65	47	72
	50-100 days	45	39	87
	100-154 days	20	17	85
	159-280 days	40	33	82

TABLE III.—STORED CALF LYMPH WHEN USED FOR THE VACCINATION OF CALVES.

Length of time in days during which lymph was preserved in tubes before using.	Number of insertions made with it on calves.	Successful insertions on calves.	Insertion success rate, percentage.
2	3,998	3,390	84·7
4	1,438	1,139	74·2
6 to 8	255	184	72·1
9	431	309	71·6
11 to 12	337	273	70·6
14	263	214	81·3
16	288	207	71·9
17 to 46	639	472	73·8
53 to 93	445	332	74·6
100 to 200	388	258	66·5
200 to 500	104	17	16·3
500 to 600	135	45	33·3
600 to 700	82	24	35·0
816 to 858	72	4	5·5

In comparing the table on pages 79 and 81 of lymph preserved in tubes with that of lymph preserved on points, it will be noticed that whereas the tube lymph seems to gain in activity during the first one hundred days of keeping, and is less to be depended upon during the early days of its preservation, the lymph on the points is most active during this period: hence the rule that if you are taking lymph to use immediately or within a month, take it on points; but if you require the lymph for later vaccinations, take it in tubes. Always be most scrupulous in recording the source of your preserved lymph. This is, of course, necessary in all public vaccinations, but it is as morally obligatory to you in your private practice.

Having described the best methods, as far as we know, of vaccinating from arm to arm, and with preserved lymph, we will next consider the number of places that vaccination should be performed in. Evidence has been collected and reasons given on pages 7 to 10 showing, we think, the greater benefit that is derived from making multiple insertions, and we have arrived at the decision that five separate

vesicles is the best number to make. That one large vesicle having an equal area with the combined areas of the separate vesicle is not equally beneficial we consider true from the side both of practice and theory.

In a report of a committee on vaccination to the Epidemiological Society, published in vol. v., new series of their 'Transactions,' p. 163, the committee (consisting of Mr. Shirley Murphy, Dr. John MacCombie, and the author) state that they are disposed to regard number and area of scars as by no means convertible terms.

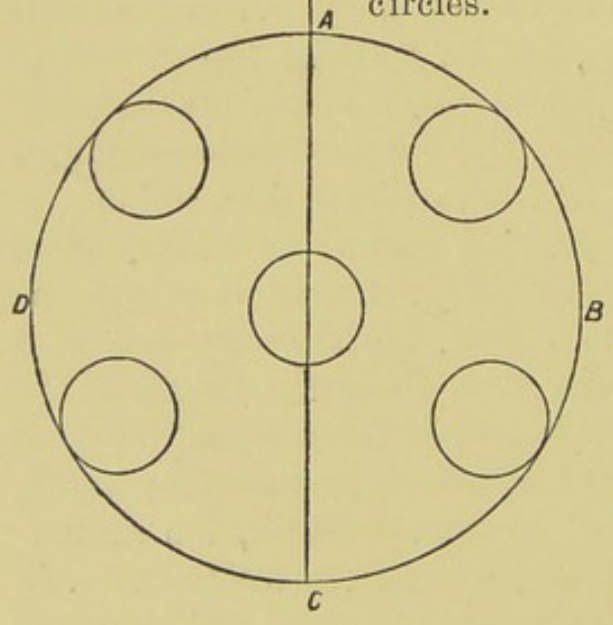
The following consideration will also help to settle this question:

The chemical produced, formed by the growing vesicle, is absorbed by the lymphatics, and thrown ultimately by the circulation all over the body. Now, the growing portion of the vesicle is its circumference, thus the circumference is the important part to consider and not the area. If, again, as there is every reason for believing, the growing vaccine is a form of ferment, a rough analogy will help to elucidate this.

The fermentation of saccharine solutions is brought about by an organism called yeast. While this organism is growing the process of fermentation goes on, and the sugar is converted into alcohol, but as soon as the growth is complete, the completed growth ceases to convert the sugar into alcohol. Indeed, this completed growth is analogous to the completed growth of the vaccine vesicle, which constitutes its area. In the growing part alone is the product produced, and this, as before said, corresponds to the circumference of the vesicle. Now, the circumference of a circle is slightly more than three times the length of the diameter, viz. 3·14159, but it may be taken for all practical purposes as three times the length of the diameter; hence, if there are five circles of 10 mm. diameter, the circumferences of these will equal (10 mm. × 3) 5 = 150 mm. in length, and 150 mm. circumference will equal a circle whose

diameter is $\frac{150\,\text{mm.}}{3} = 50$ mm. To represent this graphically let five circles, each of a diameter of 10 mm., be drawn inside the area of a larger circle, A B C D, having a diameter, A C, of 50 mm. This is $\frac{1}{3}$ of the line E C, which represents the length of the extended circumferences of the five smaller circles. The circle, A B C D, will represent the size of a single vesicle which would have to be made to produce the effect of the five smaller vesicles. It is obvious that this circle is greater than the combined areas of the smaller circles. It is, in fact, five times larger.

The healing of a vesicle the size of the larger circle, as every surgeon knows, would require a much longer time, and while healing would offer much greater facility for extraneous organisms, such as erysipelas, being developed upon it, than the five smaller circles.



There can, therefore, be little doubt that it is better to vaccinate in a multiple number of places, than to endeavour to make one large vesicle equivalent to the smaller ones.

There is one point further we may learn from the tables to be found on pages 33 and 54: we can see that the

good we are doing by increasing the number of cicatrices is a diminishing one, while the evil that we are doing is an increasing one; so that, in order to do the most good, we arrive at a point where the good balances the evil. Mr. Marson was of the opinion that the greatest amount of good with the least amount of evil was arrived at when he made five or six places. We, after a considerable amount of practice, have arrived at the same conclusion, so that we consider five places as the proper number to vaccinate in. Let it be remembered that the people who come up to the public vaccination stations are usually of the uneducated class, which are numerically the chief opponents to vaccination. These people will only have their children once vaccinated according to law. It is, therefore, incumbent upon us as medical men to give them that kind of vaccination which will last them the longest time with the least amount of evil, and we have said, after weighing all the evidence we can collect, that five is the proper number of insertions to make. Among the educated class it is not so incumbent upon us to make the larger number of insertions, because there is not the same unreasonable opposition to vaccination as in the uneducated class, and they will have no objection to re-vaccination when it is urged upon them; but we think it right to insist upon the five places among this class also, because the better educated class should set an example to those who are less fortunate.

Now, it has been seen that vaccinations performed with preserved lymph are not nearly so successful as vaccinations performed with perfectly fresh lymph from arm to arm, and it follows that we should vaccinate as far as possible from the more active kind of lymph. In a large London vaccination station it is possible to keep up a constant supply week by week of healthy infants, so also in large country towns; but in the small places a weekly supply of healthy children cannot be maintained. In these latter places, therefore, the fresh lymph supply will frequently be interrupted, and vaccination from preserved lymph will often have to be resorted to.

To obviate this evil as far as possible, it has been ordered by the Local Government Board in those districts where the vaccinations are too few to ensure a weekly supply of fresh lymph, that the vaccinations be done periodically, say every quarter. The first two or three healthy children are vaccinated with preserved lymph, and from these the number which next comes up to the station the following week are vaccinated. It will at once be seen that this arrangement offers the minimum amount of vaccination with preserved lymph. This regulation often appears irksome to those who have not reflected upon it. It will be also plain that the regulation enables the vaccinator to generate his own supply of lymph, and this, of course, is most desirable; for otherwise very large demands would fall upon the central office for the supply of vaccine lymph, and this supply would be largely used by lazy practitioners, to the detriment of the vaccination of the community. There is also a rule insisting that all children should be vaccinated at the public stations, and all that have been so vaccinated should be inspected at the same. This regulation, of course, obviates the evil arising from carrying preserved lymph to the houses of patients who it may be wished in this way to please.

We have already spoken of the treatment of the vesicle if abnormal, and have cautioned against the use of shields (p. 45). When the vesicle is normal only a dry piece of clean linen rag should be laid over it and secured in place with a few stitches. This should be changed morning and night.

Poultices when ignorantly applied not only cause the removal of the scab before its time, but produce auto-inoculation of the surrounding skin.

There is another bad practice which we have had occasion to witness several times, and that is, the taking the names of the vaccinees on a separate piece of paper, and entering them afterwards in the register. No doubt this practice has been brought about by the laudatory intention

of keeping the register neat, but here neatness is acquired at the expense of exactness, and the register had rather be exact than neat. We do not mean to imply that neatness is not to be aimed at, but only that any method by which neatness is acquired should not be one where exactness is likely to be sacrificed. Always have the register with you, and enter all the names of the vaccinees present, before you proceed to vaccinate. It will then be easy to enter the source of your lymph supply. Always be scrupulously punctual at your station; be firm, yet courteous, in your behaviour; and insist upon vaccinating in the manner you consider best. We should always remember that it is our duty to educate our patients in professional subjects, not for them to educate us.

We will now consider the modifications of practice we have to exercise in animal vaccination.

First of all let us consider the premises and construction of an ideal station, and we here give a plan of such for a large station of, say, 7,000 vaccinations a year.

Secondly, as to the furniture required. For the waiting-room about 200 wooden-bottomed chairs, with an equal number of wooden stools for nursing mothers to place their feet upon, and a good-sized table to place packages, etc., with a large umbrella-stand, and perhaps a clock, is all the furniture requisite in this room. The floors are best made of concrete, without carpet or other covering.

For the operating-room two tables are necessary, but three are more convenient for the vaccination of the calves, and a weighing-machine. The construction of these tables is shown in the plan, which is drawn to scale. The tops are made movable, so that when tilted up the calf can be partially secured to it while standing. The top is then turned so that the calf lies on the table. The man who has helped to turn the table up, and is now placed at the back of the animal, seizes the uppermost fore-leg and bends it upon itself, holding the bent limb near the body of the beast. This manœuvre usually renders the beast

unwilling to struggle, but if it does struggle it gives the man great control over it. The head is then secured, and the uppermost hind-leg is immediately afterwards fastened to the iron upright. But before this is done it is well to wrap a piece of saddle stuffing round the leg of the animal to prevent the rope and the iron hurting it. The fore-legs are then secured by the leather straps, and the calf is ready. The other calf is then similarly prepared. As the vaccinated calf will be retained the longer on the table, in order to obtain the vaccine lymph, it is humane to put this one on the table last.

The calf to be vaccinated should be shaved previously from the umbilicus to the groin, and the shaved portion of the skin washed with a piece of sponge soaked in a solution of perchloride of mercury, containing one part of perchloride to 1,000 parts of water. Two or three grains of chloride of ammonium will render the perchloride of mercury more soluble, so this salt may be added. The vaccinated animal should also be washed over the area on which the vesicles are situated with the same lotion, and immediately after the lotion with clean water. (The Fig. shows the amount of surface shaved, the number of vesicles, and the manner of putting on the forceps to obtain the lymph.) After the animal is vaccinated, a cradle is placed on its neck as soon as it is returned to its stall. The cradle is to prevent the animal from licking its vaccinated places.

The calves should be well fed during the course of their vaccination on milk and hay. The milk should be boiled and allowed to cool before giving it to the calves. This is important, especially during the hot weather, as it prevents the diarrhœa, which is so detrimental to the development of the vesicles, and is so prevalent among the calves fed with raw milk during the hot season. Upon the fourth day, but not later than the fifth after vaccination, the lymph can be taken from the calves to vaccinate other calves or children. In hot weather the earlier day is the better. It will be noticed that this is at least three days

GROUND FLOOR.

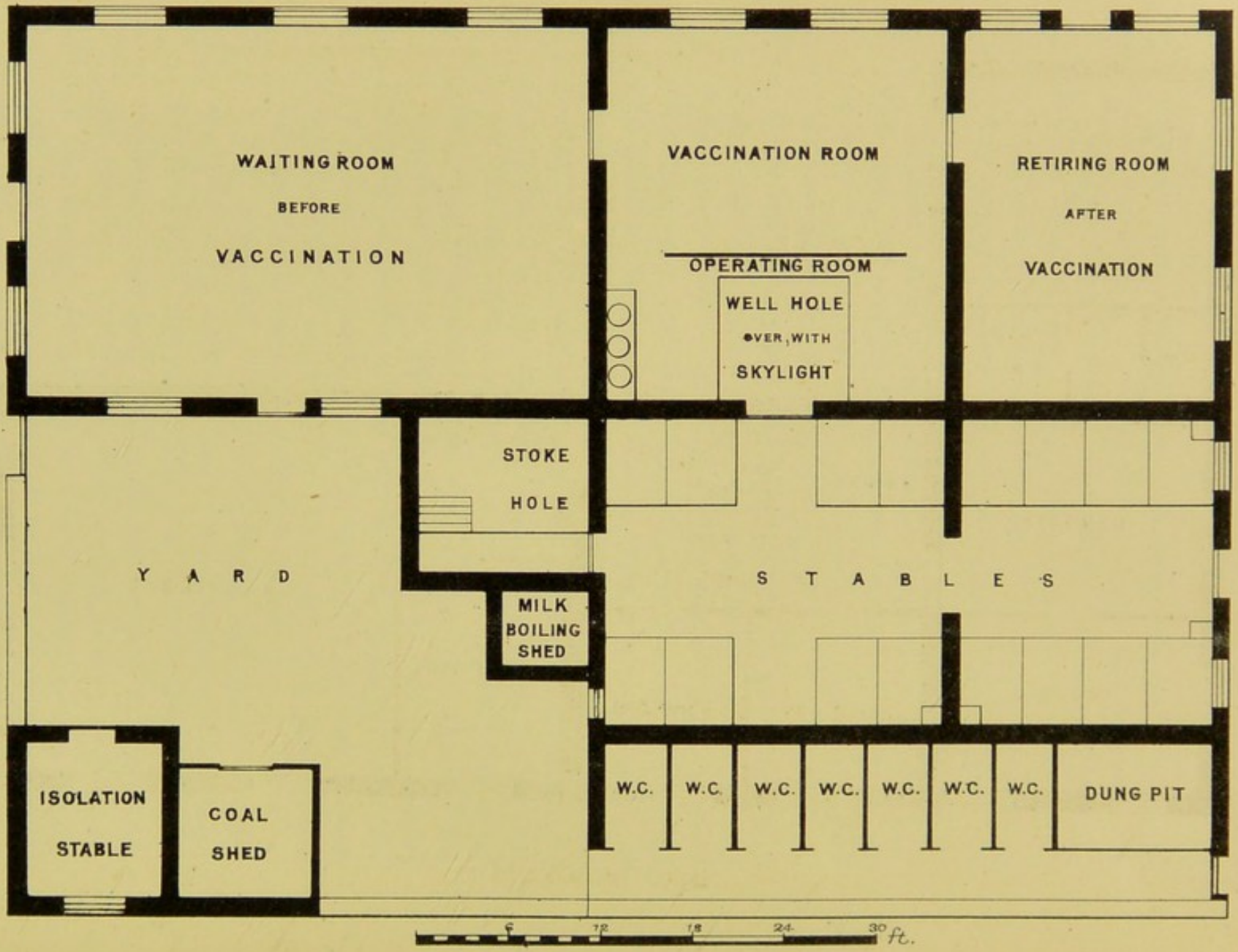
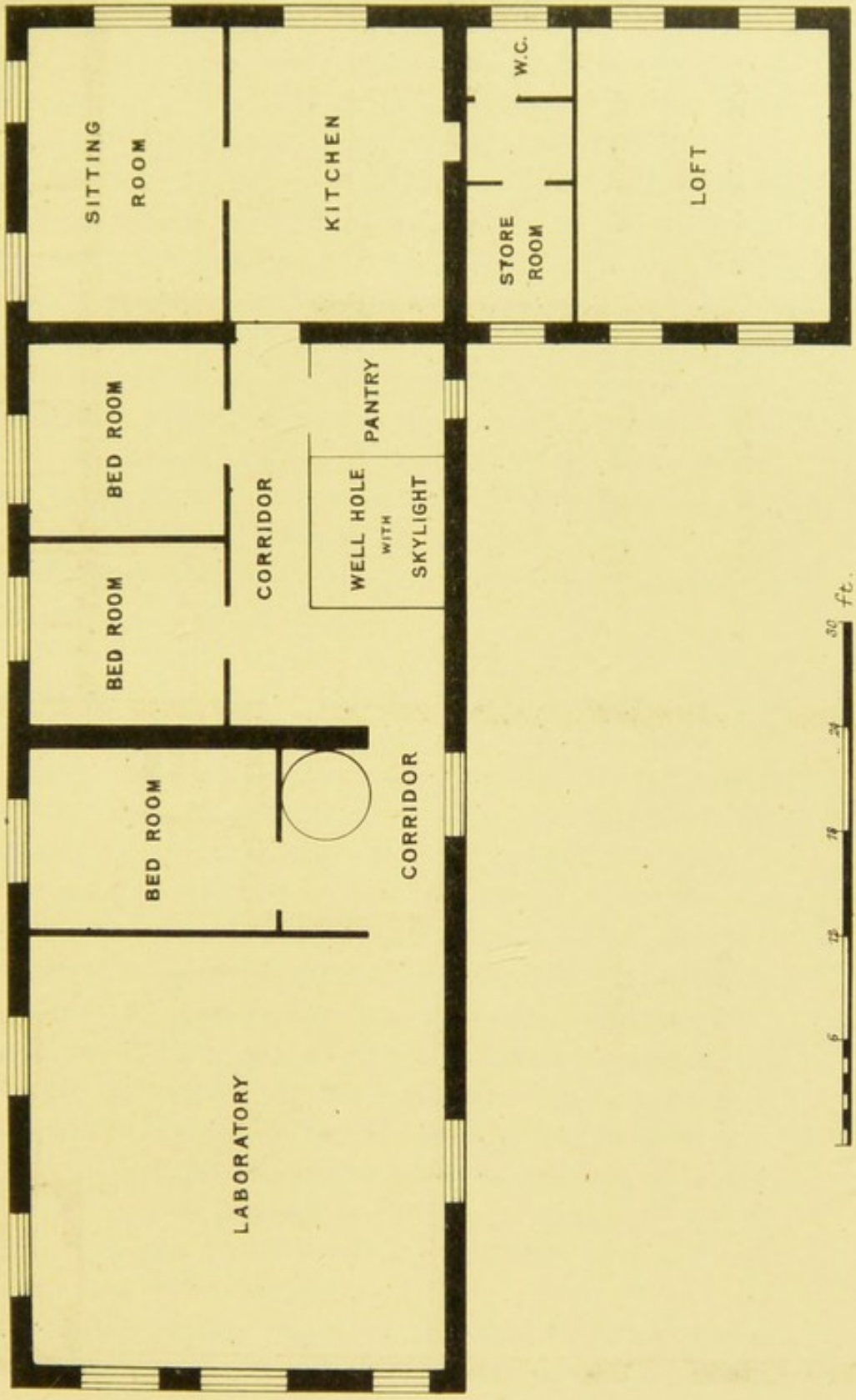


PLATE XII.

West Newman lith.

PLATE XIII.



FIRST FLOOR.

West, Newman lith.

earlier than it is customary to take lymph from the human infant, which is the eighth. This, indeed, is the latest day that it is justifiable for taking the lymph from them. Lymph taken from the calf later than the fifth, and from the human infant later than the eighth, is not to be depended upon, for often it will produce sores, if any, which are not protective against further vaccination, as in the human infant, which has already been shown (p. 57). One reason of the more rapid development of the vesicles on the calf, probably, is the higher temperature of the young animal than of the human infant, the normal temperature of the former being 102·63°, whereas that of the latter is only 98·87°, the difference being 3·76° higher in the calf. The chart will show the relative temperatures of the two animals during the course of vaccination.

It will be noticed that the maximum temperature occurs on the seventh day in the human infant, whereas it occurs on the fourth or fifth day in calves, and this latter fact corresponds with the earlier day on which the lymph is better taken from these animals. It is as important to use the lymph taken directly from the calf to perform vaccination on another calf or on children, as it is to use the human lymph taken directly from another arm. When it is necessary to preserve animal lymph, it is customary to take it either on points or tubes. The same rules as obtain in the use of human preserved lymph are applicable to the use of animal lymph. If vaccinations are to be performed with preserved lymph during the first fortnight of its preservation, the lymph should be taken on points; if longer, then tubes will give the better result. In using calf lymph in tubes it is best to blow out the contents of five or six tubes, and mix them altogether.

The foregoing tables show the relative keeping power of the lymph as used for the vaccination of calves or infants. A register should always be kept of the names, the addresses, the age, the sex, the number of places vaccinated, the number of successful places, the source of the lymph

Chart A.

SHOWING TEMPERATURE OF VACCINATED CALVES.

[*The continuous line represents the temperature of males, the intercepted line that of females.*]

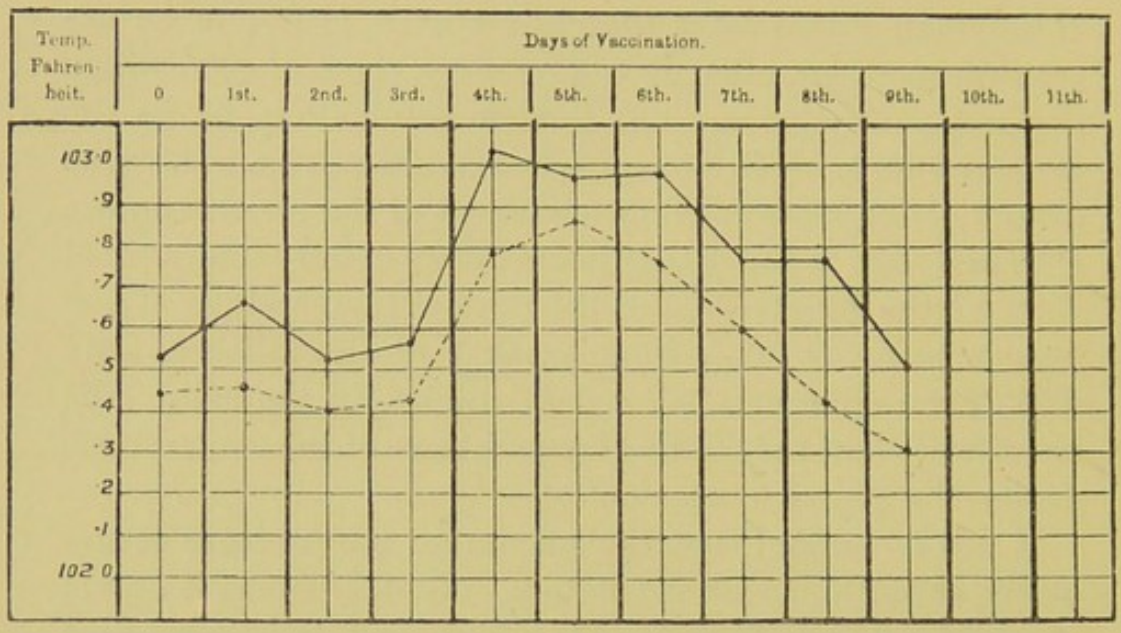
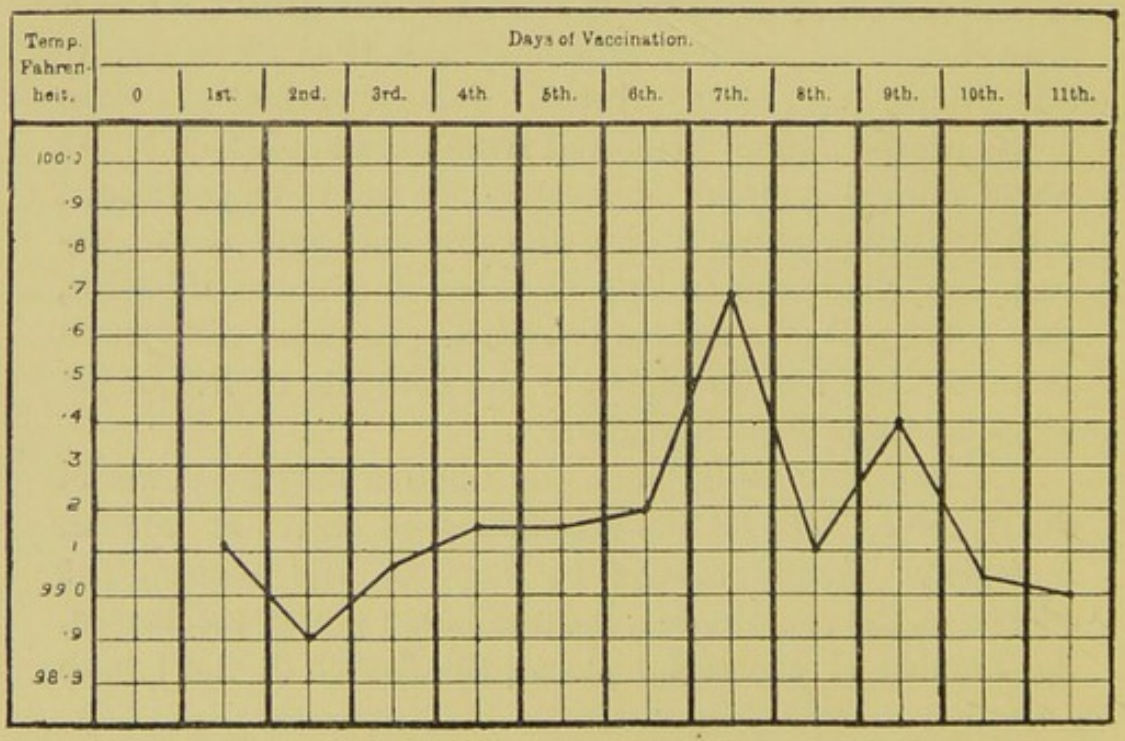
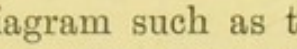


Chart B.

SHOWING THE TEMPERATURE OF VACCINATED INFANTS.

[*As regards day of vaccination, temperature taken after performance of the operation.*]



used, and the date of inspection. The register should always be with you while vaccinating, so that the names be entered at the time, and the source of the lymph recorded. You should arrange for all those infants who have been vaccinated to come back on the day week to the station, and it is very useful to make some record of the condition of the arm. This is conveniently done by a small diagram such as this, 

, where *a* represents the average size of the vesicle, and *b* represents the extent of the areola, if any, on the eighth day.

You should on no account take the lymph to your patient's house, because you will necessarily be using preserved lymph, and this should never be used when it can be avoided, for failure is so much more frequent after its use. All to be vaccinated ought to be made to come up to the station at an appointed hour on a certain day, or days, of the week, and the vaccinations performed either from arm to arm or from calf to arm. If the number of cases in a given district be too small to keep up a regular weekly supply of fresh lymph, periodical vaccinations then are the best, for the first one or two cases can be done with preserved lymph and the rest from successful cases of the first one or two.

The following observations may be made during the course of a primary human vaccination:

Days of Vaccination.

First.

Notice in some cases, when first vaccinated, the skin at the parts scratched immediately seems raised; this is due to a provoked urticara, and is indicative of the tendency of the skin to this eruption.

Second.

Notice the slight redness at the parts scratched, and that they are as yet level with the general surface of the skin.

The temperature of the individual is scarcely, if at all, raised.

Third.

Notice that the redness has slightly increased, and that the parts inoculated feel shotty. The temperature is a little raised.

Fourth.

The redness has still further increased; the points of inoculation not only feel shotty, but are slightly raised, and are generally commencing to be vesicular. The temperature is slightly higher than on the third day.

Fifth.

Notice that the inoculated places are distinctly vesicular. The temperature remains nearly the same as on the fourth day.

Sixth.

The vesicles, which now appear, are more or less distinct, several of them being crowded over each area of inoculation. The temperature is further slightly raised.

Seventh.

Many, if not all, the vesicles which were crowded over an inoculation area have become confluent. The temperature, comparatively, is much higher, and has reached its maximum, *i.e.*, about $\frac{1}{2}^{\circ}$ C. above the normal.

Eighth.

This is the usual day for taking the lymph. It may be taken before, but not after. The areola begins to form, but it never should be excessive. The temperature falls a little more than it rose on the seventh day.

Ninth.

The areola is now at its height. The temperature again rises a little.

PLATE XIV.

Fig. 1.

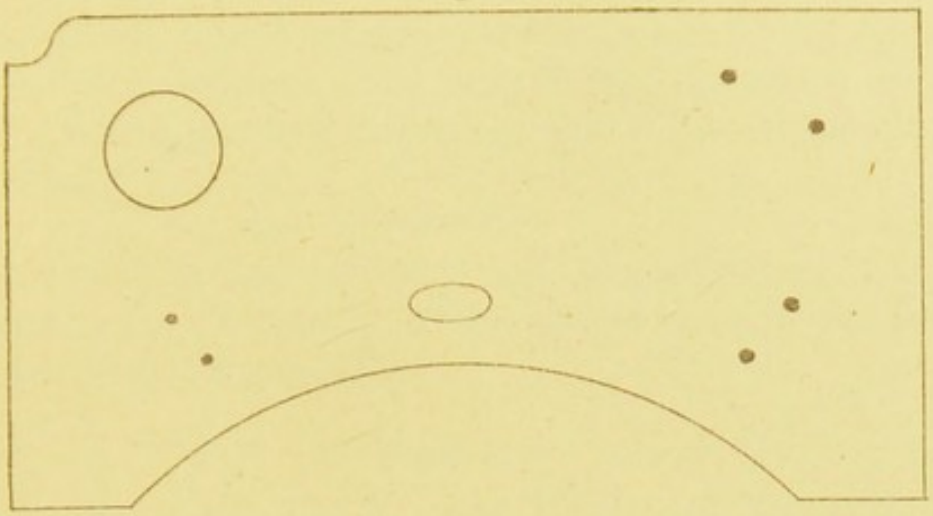
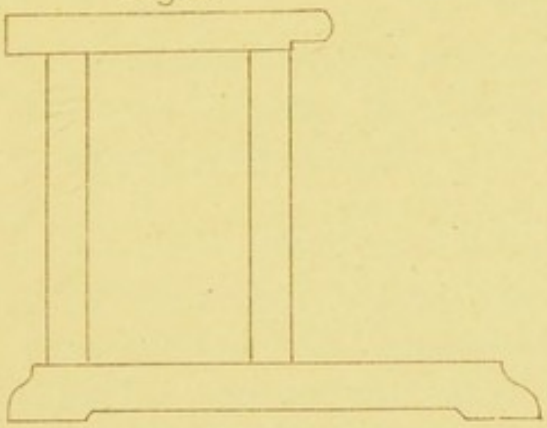
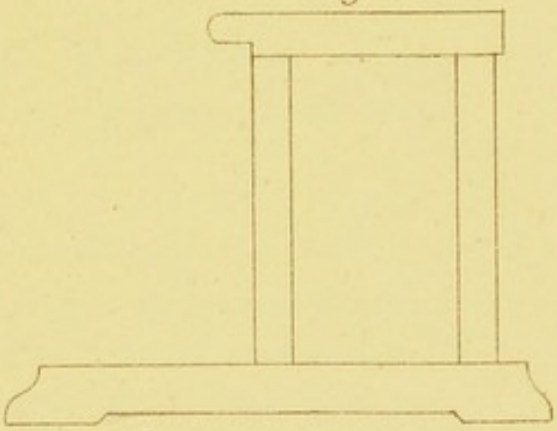


Fig. 2.



Left hand end

Fig. 3.



Right hand end.

Fig. 4.

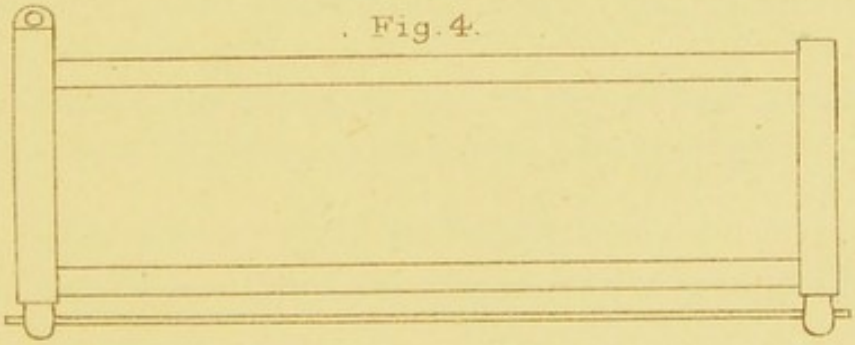


Table as seen from above with top off.

West, Newman lith

Tenth.

The areola is still extensive, and is not declining. The centre of the vesicle is undergoing change, and the vesicles are themselves at their maximum size. The temperature has fallen.

Eleventh.

The areola is fast declining, and the alteration in the appearance of the centre of the vesicle is more marked, and extending centrifugally.

Twelfth.

The areola has almost quite faded, and the scab is gradually drying from the centre towards the circumference.

Twenty-first.

The scabs usually fall on this day, leaving healthy cicatrices, unless they have been interfered with by poultices or ointments.

Concerning Re-vaccinations, etc.

Hitherto there has been no satisfactory classification of these adopted. One author will give a large percentage of these as unsuccessful; another will give a far less percentage, depending upon what one and another regards as successful in the various manifestations of the sore produced by a re-vaccination. The following is an endeavour to give some scientific classification which shall be regular in its working amongst different observers.

The following classification has been adopted at the animal vaccine establishment since its commencement.

Classification of Re-vaccinations.

(0) are those cases on whom re-vaccination produces no results.

(1) are those cases on whom there is scarcely any areola, and the sore does not advance after the fourth day, and never becomes truly vesicular.

(2) are those cases which do not advance after the sixth day, become vesicular, and have a moderately extensive areola, which has declined by the eighth day. On this day the scabs are darkening.

(3) are those cases on whom there has been a more or less extensive areola, which is declining on the eighth day; by this day, also, the vesicles are fully formed, and only slightly, if at all, darkening.

(4) are those cases on whom the areola is at its height on the eighth day.

(5) are those cases on whom the areola, though present, has not attained its height on the eighth day.

(6) are those cases resembling in all respects primary vaccination.

The following Tables IV. and V. have been drawn up, showing the practical results of the classification adopted.

Table IV. contains those cases which have been once previously vaccinated, and Table V. contains those cases which have been more than once previously vaccinated.

In Table IV., column 1, are given the characteristic numbers of the classification. In column 2 the number of cases which fall under the different characteristics is given; in column 3 the range of ages is given; in column 4 the aggregate age of all the cases under the specified characteristics is given, and the aggregate age divided by the number of cases in column 2 will give the average age of those re-vaccinated, and they are given in column 5.

In order to form an approximate estimate of the proportion of cases which are more or less influenced by other causes than by the lapse of time, it is necessary to form some idea of the age of presumably normal cases, *i.e.*, those on whom time alone influences the return to susceptibility.

Now, it will be seen on reference to Table IV., column 5, that 18·08 is the average age at which all are re-vaccinated, and, further, that 18 is the age at which those in the mean characteristic, or No. 3, are re-vaccinated. It may therefore

Table IV.

CONTAINING THOSE ONCE PREVIOUSLY VACCINATED FROM 1882 TO MARCH, 1895, AT LAMB'S CONDUIT STREET AND SOUTHAMPTON ROW. MALES, FEMALES, AND THOSE WHOSE SEX IS NOT RECORDED.

Characteristic number.	Number of cases.	Range of ages.	Aggregate age.	Average age.	Hypothetical age.	Calculated number of exceptional individuals.	Percentage of exceptional individuals to number of cases in Col. 2.	Percentage of exceptional individuals to total number of cases, viz., 5075.
6	156	2 to 65	2806·3	17·91	24	50·93	32·65	1·00
5	348	5 to 65	7029·85	20·20	22	38·23	19·86	·75
4	997	3 to 75	18539·75	18·59	20	97·17	9·75	1·91
3	1668	4 to 60	30017·85	18	18			
2	1463	3 to 59	24938·7	17·05	16	147·04	10·05	2·89
1	390	1·6 to 61	7629	19·27	14	247·92	62·61	4·88
0	53	7 to 52	1102	20·79	12	72·70	137·17	1·43
Total	5075	1·6 to 75	91862·6	18·08		653·99	10·92	10·92
?	376	·4 to 36	8125·7	21·61				
	5457	·4 to 75	99988·3	18·32				
Cols.	2	3	4	5	6	7	8	9

Table V.

CONTAINING THOSE MORE THAN ONCE PREVIOUSLY VACCINATED FROM 1882 TO MARCH, 1895, AT LAMB'S CONDUIT STREET AND SOUTHAMPTON ROW. MALES, FEMALES, AND THOSE WHOSE SEX IS NOT RECORDED.

Number of cases.	Range of intervals.	Aggregate interval.	Average interval.	Hypothetical interval.	Calculated number of exceptional individuals.	Percentage of exceptional individuals in Col. 2a.	Percentage of exceptional individuals to total number of cases, viz., 1113.	Number to be added or subtracted from the calculated number in Col. 7a to make the per cent. in Col. 8a equal.	Percentage of number in col. 10 to number in Col. 2a.	Aggregate age at present vaccination.	Average age at present vaccination.	Difference between average interval and age, being the age at first revaccination.
5	3 to 12	35·5	7·1	24	4·59	91·8	·41	−1·15	−23	81	16·2	9·1
33	2 to 36	383	11·61	22	20·90	63·3	1·88	+1·77	+5·36	1075	32·58	20·97
95	·04 to 30	999	10·51	20	62·53	65·82	5·62	+2·73	+2·87	2596	27·33	16·82
215	·02 to 30	2329·52	10·83	18	124·17	57·75	11·16	+23·53	+10·94	6208	28·87	18·04
390	·04 to 30	3639·9	9·33	16	249·77	64·04	22·44	+18·16	+4·66	10399·04	27·07	17·74
338	·08 to 41	2505·98	7·41	14	264·71	78·32	23·78	−32·5	−9·62	8784·61	25·99	18·58
37	·02 to 23	207·02	5·59	12	36·97	99·92	3·32	−11·55	−31·22	880·03	23·78	18·19
1113	·02 to 41	10099·92	9·07		763·64	68·7	68·7	·99	·09	30023·68	26·98	17·91
256	·01 to 23	2381·88	9·1	Mean 18	179·38	70·07	13·10	+8·76	+3·42	6758·84	26·40	17·09
1369	·01 to ·41	12481·8	9·14		927·42	67·75	67·75			36782·52	26·88	17·79
2a	3a	4a	5a	6a	7a	8a	9a	10	11	12	13	14

be inferred that No. 3 contains very few, if any, of the abnormal cases. It may also be inferred that the two characteristics on either side of 3, *i.e.*, characteristics Nos. 2 and 4, will contain fewer of the abnormal cases than those more remote from 3; yet we may safely assume that they will contain some. No. 2 is ·95 less than 18, and No. 4 is ·59 greater than 18, or on an average ·77 difference; the allowance must be made for the abnormal cases they contain. Let it be assumed that the figure ·77 may be taken as 2, and let it also be assumed that the characteristics are regular, *i.e.*, they represent equal increments of time that would elapse before each consecutive characteristic would be reached on the return to susceptibility. Then, on making additions of 2 to 18 as the characteristic numbers ascend, and deductions of 2 as they descend, we get 20, 22 and 24 on the one hand, and 16, 14 and 12 on the other. These may be called hypothetical ages, and they are given in column 6. From the above considerations it follows that if time alone had to be considered, an individual is by a single infantile vaccination rendered immune to further vaccination for fourteen years. As 6 represents the re-vaccination, which resembles in all respects a primary vaccination, the individuals which have the greatest tendency to return to their susceptible condition will be collected together under this class. They may be called unstable with respect to their former vaccination. The number of the unstable individuals will gradually diminish in the characteristic as No. 3 is approached.

Again, as 0 represents that no result follows re-vaccination, all the individuals which have an opposite tendency to those just mentioned, and who may be called the stable individuals, will be collected under that characteristic. These, it may be inferred, will gradually diminish as No. 3 is approached. The unstable individuals will tend to diminish the average age, while the stable individuals will tend to increase it to what it would have been if time alone had to be considered.

In characteristics Nos. 6, 5, and 4, containing as they do

the majority of the unstable class, this unstable class must be subtracted in order to raise the average up to the hypothetical ages; but in characteristics Nos. 2, 1, and 0, containing the stable class, unstable cases must be added in order to bring down the average to the hypothetical age. For, as we have just said, the inclusion of unstable cases diminishes the average age, 5·59 years being the average interval which elapses between one re-vaccination and another, as given in Table V., column 5*a*. And as we may fairly assume the cases under this characteristic are, the vast majority of them, stable individuals, we may approximately take 5·59 years as the average period during which the stable individuals enjoy immunity.

From the above data we can formulate the following equation for characteristic 6.

Let x represent the number of unstable individuals, which must be subtracted from the number in column 2, *i.e.* 156, in order that the average age given in column 5, *i.e.* 17·91, may be brought up to the hypothetical age given in column 6, *i.e.* 24.

Hence $x \times 5{\cdot}59$ (*i.e.*, x multiplied by the average period during which the stable individuals have immunity, for this at most must be the longest average time that unstable individuals have immunity) will give approximately the aggregate age of the unstable individuals; and if we take the number from 2806·3, the aggregate age of all the cases given in column 4, we get $2806{\cdot}3 - 5{\cdot}59\ x$, and this divided by 156, the total number of cases less by x, will give us the average age of those who are only influenced on their return to susceptibility by time, and this we have assumed to be 24. The equation will therefore stand thus for characteristic 6:

$$\frac{2806{\cdot}3 - 5{\cdot}59}{156 - x} = 24.$$

$$\therefore\ 2806{\cdot}3 - 5{\cdot}59x = 3744 - 24x.$$

$$\therefore\ 18{\cdot}41x = 937{\cdot}7. \quad \therefore\ x = 50{\cdot}93.$$

The equation for No. 5 will be:

$$\frac{7029 - 5{\cdot}59x}{348 - x} = 22.$$

$$\therefore\ 7029 - 5{\cdot}59x = 7656 - 22x.$$
$$\therefore\ 16{\cdot}41x = 627. \quad \therefore\ x = 38{\cdot}23.$$

The equation for No. 4 will be:

$$\frac{18539{\cdot}75 - 5{\cdot}59x}{997 - x} = 20.$$

$$\therefore\ 18539{\cdot}75 - 5{\cdot}59x = 19940 - 20x.$$
$$\therefore\ 14{\cdot}41x = 1400{\cdot}25. \quad \therefore\ x = 97{\cdot}17.$$

No. 3, it has been assumed, contains no exceptional cases.

No. 2. Here we have to add unstable cases in order to diminish the average age and make it equal to the hypothetical age.

Our equation for this characteristic will be:

$$\frac{24938{\cdot}7 + 5{\cdot}59x}{1463 + x} = 16.$$

$$\therefore\ 24938{\cdot}7 + 5{\cdot}59x = 23408 + 16x.$$
$$\therefore\ x = 147{\cdot}04.$$

Similarly the next equation for No. 1 will be:

$$\frac{7629 + 5{\cdot}59x}{396 + x} = 14.$$

$$\therefore\ 7629 + 5{\cdot}59 = 5544 + 14x.$$
$$\therefore\ 8{\cdot}41x = 2085. \quad \therefore\ x = 247{\cdot}92.$$

Similarly the next equation for characteristic 0 will be:

$$\frac{1102 + 5{\cdot}59x}{53 + x} = 12.$$

$$\therefore\ 1102 + 5{\cdot}59x = 636 + 12x.$$
$$\therefore\ 6{\cdot}41x = 466. \quad \therefore\ x = 72{\cdot}70.$$

The different values that have been found for x are given in column 7, and they represent the number of exceptional cases which are contained under the different characteristics,

and these are what were required to be found. It will be noticed that their sum is 653·99, and as there are 5,075 cases, the percentage of exceptional cases will be 12·89.

In column 8 the percentages that the calculated numbers in column 7 bear to the number of cases in column 2 are given under their respective characteristics, and in column 9 the percentages that the calculated numbers in column 7 bear to the total number of cases—viz., 5,075—are given.

Table V.—This table contains those cases which have been more than once previously vaccinated. Columns 2*a*, 3*a*, 4*a*, 5*a*, 6*a*, 7*a*, 8*a*, and 9*a* correspond, giving the same details as columns 2, 3, 4, 5, 6, 7, 8, and 9 do in Table IV.

The equations for Table V. require the negative sign throughout, because the hypothetical intervals are all higher than the average intervals. It will also be noticed that the percentages of the exception cases to the numbers in column 2*a*, which are given in column 8*a*, are more nearly equal than they are in the corresponding column 8 in Table IV., except for characteristics 6 and 0. The probable reasons for their exception will presently be given. The meaning of this generally greater equality of the percentages in column 8*a* is probably that the element of time has correspondingly less to do with the return to susceptibility in the cases of persons who have been more than once vaccinated than it has to do with those only once previously vaccinated in infancy. If this be so, then, since the element of time is more or less eliminated for those in Table V., there can be no reason why proportionally more stable individuals should be re-vaccinated at the later intervals of time than at the earlier; neither should there be proportionally more of the unstable individuals re-vaccinated at the earlier intervals. Hence, the proportion of the exceptional individuals to the number of cases given in column 2*a* ought to be about the same if the registration under the different classes be correct. There is indeed sufficient equality to show that registration was practically correct, except, as has been said, for characteristics 6 and 0.

With regard to characteristic 6, it can be seen in Table V. that there are only five out of 1,113 cases, or only 0·45 per cent., and it is more than likely that there may be some whose alleged former re-vaccination was not really successful. Then, again, with regard to characteristic 0, some of the cases were probably successfully re-vaccinated, but the re-vaccination had run so rapid a course that on the eighth day, when inspected, it was considered that they had not taken; further, those individuals who are judged not to have taken are entered as fresh re-vaccinations in the register, and nearly always the same results happen again on the next eighth day, when they are inspected. As these cases are vaccinated three times, it follows that the number of cases—viz., thirty-seven—ought to be divided by three, which would leave only 12·5 cases out of 1,113, or 11·23 per cent. That the registration was practically correct is further borne out by the fact that there really were two registrars: one, Mr. Lapidge, at Southampton Row, who registered 333 cases; the other, Mr. Adams, at 95, Lamb's Conduit Street, who registered 780 cases. Tables VI. and VII. show the similarity of the two registrations respectively, and Table VIII. compares the two comparable columns.

Column 10, Table V., contains the number of cases which must be added or subtracted from the calculated numbers in column 7*a* to make the percentages in column 8*a* equal. The calculation is thus made: Let x = the number to be added or subtracted from 4·59, so as to make the percentage in column 8*a* equal to 68·7, which is the average percentage in column 8*a*.

Thus, for No. 6 characteristic the following equations can be formulated:

$$\frac{(4{\cdot}59 \pm x)100}{5} = 68{\cdot}7.$$

$$\therefore\ 459 \pm 100x = 343{\cdot}5.$$

$$\therefore\ x = \pm 1{\cdot}15\text{; and by trial we find that } x = -1{\cdot}15.$$

Similarly, the equation for No. 5 characteristic will be:

$$\frac{(20 \pm x)100}{33} = 68{\cdot}7. \quad \therefore\ x = +1{\cdot}77.$$

Similarly, the equation for No. 4 characteristic will be:

$$\frac{(62{\cdot}53 \pm x)100}{95} = 68{\cdot}7. \quad \therefore\ x = +2{\cdot}73.$$

Similarly, the equation for No. 3 characteristic will be:

$$\frac{(124{\cdot}17 \pm x)100}{215} = 68{\cdot}7. \quad \therefore\ x = +23{\cdot}53.$$

Similarly, the equation for No. 2 characteristic will be:

$$\frac{(249{\cdot}77 \pm x)100}{390} = 68{\cdot}7. \quad \therefore\ x = +18{\cdot}16.$$

Table VI.

CASES MORE THAN ONCE RE-VACCINATED AT SOUTHAMPTON ROW, 1884 TO 1885, REGISTERED BY MR. LAPIDGE.

Characteristic numbers.	Number of cases.	Range of intervals.	Aggregate interval.	Average interval.	Hypothetical interval.	Calculated number of exceptional cases.	Percentage of exceptional cases to numbers in Column 2.	Number to be added or subtracted from the calculated numbers in Column 7 to make the percentage equal in Column 8.	Percentage of numbers in Column 9 to those in Column 2.
6	2	3 to 7	10	5	24	2	100	−·70	−35·16
5	10	3 to 36	121	12·1	22	6·14	61·4	+·344	+3·44
4	17	3 to 30	185	10·82	20	10·97	64·53	+·0528	+·31
3	61	1 to 33	690	11·32	18	33·63	55·13	+5·92	+9·7
2	88	16·30	951·41	10·81	16	45·07	51·22	+11·99	+13·62
1	134	·08 to 15	1086·6	8·11	14	97·10	72·46	−10·21	−7·62
0	21	·02 to 23	123·27	5·87	12	21	100·	−7·38	−35·14
	333	·02 to 36	3167·28	9·51		215·91	64·84	0	0
?	70	·02 to 25	612	8·74	Mean taken. 18	53·39	76·27	−8	−11·43
	403	·02 to 36	3779·28	9·37	18	286·46	71·08	0	0
Cols. 1	2	3	4	5	6	7	8	9	10

Table VII.

CASES MORE THAN ONCE RE-VACCINATED AT LAMB'S CONDUIT STREET, 1882 TO MARCH, 1895, REGISTERED BY MR. ADAMS.

Characteristic number.	Number of cases.	Range of intervals.	Aggregate interval.	Average interval.	Hypothetical interval.	Calculated number of exceptional cases.	Percentage of exceptional cases to number in Column 2.	Number to be added or subtracted from the calculated numbers in Column 7 to make the percentages in Column 8 equal 68·59.	Percentage of numbers in Column 9 to those in Column 2
6	3	6 to 12	25·5	8·5	24	2·48	82·6	−·42	−14·08
5	23	2 to 23	262	11·39	22	14·55	63·26	+1·23	+5·35
4	78	·04 to 28	814	10·44	20	50·51	64·76	+2·99	+3·83
3	154	·02 to 30	1639·52	10·65	18	88·68	57·61	+16·91	+10·33
2	302	·04 to 30	2688·49	8·90	16	199·03	65·9	+8·11	+2·68
1	204	·08 to 24	1419·88	6·96	14	163·81	80·30	−23·89	−11·71
0	16	·25 to 22	83·75	5·23	12	15·99	99·94	−5·02	−31·37
Total	780	·02 to 30	6932·64	8·88		556·64	71·36		
?	186	·01 to 33	1769·88	9·52	Mean taken. 18	123·58	66·44	+10·99	+5·91
Total	966	·01 to 33	8702·52	9·01	18	758·58	78·53		
Cols. 1	2	3	4	5	6	7	8	9	10

Table VIII.

Characteristic number.	Numbers to be added or subtracted from Column 7, Table III., to make the percentages in Column 8, Table III., equal.	Numbers to be added or subtracted from Column 7, Table IV., to make the percentages in Column 8, Table IV., equal.	Percentage of characteristic number to total number of cases.	Percentage of characteristic number to total number of cases.
	Lapidge.	Adams.	Lapidge.	Adams.
6	−35·16	−14·08	·6	·38
5	+3·44	+5·35	3·00	2·95
4	+·31	+3·83	5·10	10·
3	+9·7	+10·33	18·32	19·74
2	+13·62	+2·68	26·42	38·72
1	−7·62	−11·71	40·24	26·15
0	−35·14	−31·37	6·31	2·05

Similarly, the equation for No. 1 characteristic will be:

$$\frac{(264{\cdot}71 \pm x)100}{338} = 68{\cdot}7. \quad \therefore\ x = -32{\cdot}5.$$

Lastly, the equation for 0 characteristic will be:

$$\frac{(36{\cdot}97 \pm x)100}{37} = 68{\cdot}7. \quad \therefore\ x = -11{\cdot}55.$$

The different values found for x—and these represent the numbers that have to be added or subtracted from the number in column 7*a* to make the percentages in column 8*a* all equal—are given in column 10.

In column 11 the percentage of the numbers in column 10 to the number of cases contained in column 2*a* is given.

In column 12 the aggregate age of all the cases under the several characteristics is given for the present re-vaccination.

In column 13 the average age is given, found, of course, by dividing the aggregate age by the number of cases in column 2*a*.

In column 14 the difference between the average age in column 13 and the average interval in column 5*a* is given, and this must necessarily be the average age at which the first re-vaccinations took place.

LECTURE VI.

ON THE RELATION OF COW-POX, HORSE-POX, AND CAMEL-POX TO SMALL-POX.

The view that cow-pox and horse-pox are simply modifications of human small-pox, and owe, not only their origin, but their continued existence to it, is one which has commended itself to many since Jenner's time, for it accounts readily for most of what may be called the peculiarities, both of cow-pox and horse-pox, and it saves us from many difficulties which meet us on the contrary supposition, viz., that cow-pox is an independent disease.

A good instance of these difficulties, and how they are met, is seen in Dr. Ballard's prize essay on vaccination,* pp. 32, 33, where he, while admitting that the cow can be inoculated with small-pox virus, and that the lymph collected from the resulting vesicles is so modified that it no longer produces small-pox but only cow-pox, yet explains it on the hypothesis that they are independent diseases, by supposing, on the one hand, that the cow is incapable of developing small-pox, therefore when the cow is inoculated with small-pox virus it is cow-pox which is produced; on the other hand, he supposes that man is capable of developing both his own special disease, small-pox, and the varioloid disease of the cow. Hence that cow-pox, however arising in the cow, whether by the direct inoculation of small-pox virus or by

* 'Vaccination, its Value and Alleged Dangers,' a prize essay, by Edward Ballard, M.D., 1868.

some other occult manner, remains cow-pox always when again transmitted to man.

A right understanding of this matter is one of great practical importance, for if it be true that cow-pox is but modified small-pox, then no longer must we regard the human body as a soil foreign to the vaccine virus, but rather the cow's, and thus a weighty argument now used in favour of animal vaccination would have to be transferred to the opposite balance. One instance may be given of how the view that vaccinia is an independent disease operates. Dr. Ballard, in the work already referred to, on p. 241, speaking of the care to be taken in selecting cases for vaccination, says: 'He (the vaccinator) should remember that the vaccine disease is one which is not natural to man, that it is planted on a soil to which it is *foreign*, and that it requires constant watchfulness and judicious cultivation to restrain its *inherent* disposition to deteriorate.' This passage clearly shows Dr. Ballard's view of cow-pox, and helps to explain his advocacy for animal vaccination on p. 253.

The arguments which may first be brought forward in favour of the view of the direct relation between cow-pox and small-pox are those derived from the special characteristics of cow-pox in the cow when compared with small-pox in man. It is generally admitted that the cow-pox is propagated among the cows by milking, and those who have paid most attention to the subject are agreed that it is never transmitted from one animal to another except by direct contact. The disease is never, like small-pox, conveyed by exhalations, *i.e.*, through the medium of the atmosphere. Thus it is only *milch cows* that suffer during epidemics. Jenner was convinced of this. On p. 86 of his 'Inquiry into the Causes and Effects of Variola Vaccinia,' published in 1801, he writes: 'It has been conceived to be contagious among cows without contact, but this idea cannot be well founded, because the cattle in one meadow do not infect those in another—although there may be no other partition than a

hedge—unless they be handled or milked by those who bring the infectious matter with them; and, of course, the smallest particle imaginable, when applied to a part susceptible of its influence, may produce this effect.' Ceely, also, in his 'Observations on the Variola Vacciniæ,' published in 1840, from the Transactions of the Provincial Medical and Surgical Association, writes: 'It is considered that the disease is peculiar to the milch cow, that it occurs primarily when the animal is in that condition, and that it is casually propagated to others by the hands of the milkers. . . . I have frequently witnessed the fact that sturks, dry heifers, dry cows, and milch cows milked by *other* hands, grazing in the same pastures, feeding in the same sheds, and in contiguous stalls, remain exempt from the disease.'

Both the above observers, then, agree in thinking the disease is seldom, if ever, conveyed from one animal to another except by direct contact.

Another fact may be mentioned here, showing, as far as it goes, the same thing. During the practice of animal vaccination there is not, as far as is known, a single instance on record of one animal becoming affected from another except by direct inoculation. There certainly has not been one at the Animal Lymph Establishment at Lamb's Conduit Street since it was opened in 1882, and during this time, up to July, 1895, there have been upward of 3,300 calves vaccinated there, and not one of them has been affected except by direct vaccination. Now, since in animal vaccination the true cow-pox, unmodified by transmission through man, is conveyed, this fact is of some significance.

It will scarcely be necessary to consider further evidence on this point, as no observations tend to the contrary conclusion, except some experiments made in India in 1832, of which notice will be taken further on.

How, then, does the disease arise? Jenner suggests its origin from the sore heels of horses, and no one reading his work will think that he arrived at this conclusion with-

out due observation. This opinion of his, it is true, is no longer entertained, partially because the variolous affection of the heels has been ignorantly confounded with the grease, and partially because the explanation does not account for the origin of all cases of cow-pox; but that this is the way in which the disease has occasionally been communicated to the cow seems more than probable.

Other observers, such as Ceely, offer no explanation of the origin of cow-pox. Before reflecting further upon the above peculiarity of cow-pox, it will be convenient to consider another, and that is, its localization to the udder and teats. All observers are agreed upon this point. The disease is conveyed by the milkers to the udder and teats, on which vesicles are formed, but the vesicles appear on no other part of the body. For the conveyance of the disease, it is known that the healthy hand is quite as efficacious as when it is itself affected.

Horse-pox seems also to have both the above-mentioned peculiarities of cow-pox, the only difference being that in the horse the disease is localized at the heels instead of at the udders. Horses, however, often inoculate the mouth and the mucous membrane of the nose by biting their already affected and itching heels.* The mouths of the horses are always affected subsequently to their heels.

Horses suffer quite as much as mares do from the disease, whereas in cow-pox the milch cows alone are affected.

It is stated that in Asia, in the province of Lus, the milkers have a disease long known as photo-shooter, contracted from milking the camel in the same way as cow-pox is contracted in milking the cow, and that it has been found to be equally protective against the small-pox.† Now, it is very remarkable that the cow and horse and camel should each be liable to a disease (producing vesicles so like those of small-pox, and that the lymph from them,

* Seaton's 'Handbook of Vaccination,' p. 27.

† Article, by A. W., in *Once a Week*, July 4, 1863, p. 36.

when used on man, protects him from small-pox) on those parts of their bodies which are brought into contact with the hand of man. It thus seems likely that if cows and camels were not milked, and horses were not shod, their respective varioloid diseases would cease, as far as we can see, to exist. Moreover, the parts of the respective animals which are affected are those very parts which are chiefly handled frequently by man. In order to account for the continuance of the disease, it seems necessary to suppose that it is a derivative from small-pox, and, consequently, that if small-pox became extinct, cow-pox, horse-pox and camel-pox would cease to exist. This supposition obtains much support when we find that cow-pox has become much less prevalent; and this is remarkable, for we should have expected that with the general distribution of cow-pox virus over the land for the purposes of vaccination, cow-pox, if a disease *per se*, would have increased rather than diminished. That cow-pox does prevail chiefly during great epidemics of small-pox, and that it is more rare now than formerly, are facts generally admitted; however, the following reason for thinking so may be given.

From 1838 to 1841, cow-pox seems to have again been frequent in England. It was during these years that most of the new stocks of vaccine lymph arose. Mr. Estlin met with the disease in Gloucestershire and raised a fresh stock of vaccine lymph. Mr. Fox and Mr. Sweeting also met with the disease in Dorsetshire, and raised lymph stocks.

Dr. Seaton, in his 'Handbook of Vaccination,' p. 414, remarks concerning this: 'It is certainly very singular that it (cow-pox) should have been seen by so many observers about the time, and it deserves particular notice that this was at a period when one of the most formidable epidemics of small-pox that has occurred in the present century was sweeping over the land.'

On reading Jenner's treatise 'An Inquiry into the Causes and Effects of the Variolæ Vaccinæ,' one is at once struck with the frequent occurrence of the disease in Jenner's

immediate neighbourhood, viz., Berkeley in Gloucestershire. He mentions it incidentally as occurring

In 1759	on page	47 ...	...	2,596	deaths from small-pox in London.
,, 1760	,,	13 ...	...	2,187	,, ,,
,, 1765	,,	11 ...	...	2,498	,, ,,
,, 1770	,,	9 ...	...	1,986	,, ,,
,, 1780	,,	20 ...	...	871	,, ,,
,, 1782	,,	22, 23 ...	...	636	,, ,,
,, 1791	,,	21 ...	...	1,747	,, ,,
,, 1794	,,	21 ...	...	1,913	,, ,,
,, 1796	,,	15, 16 ...	...	3,548	,, ,,
,, 1798	,,	47 ...	...	2,237	,, ,,

Besides these incidental references, we have this notable passage on page 47, from which we may infer that cow-pox was then almost of yearly occurrence. Having broken off his observations on the disease in 1796, he writes in 1801 : 'The spring of the year 1797, which I intended particularly to have devoted to the completion of this investigation, proved, from its dryness, remarkably adverse to my wishes' (this year 1797, it may be permitted to remark, was one remarkably free from small-pox in London : there were only 522 deaths in the year, and there had not been so few deaths since the year 1702, *i.e.*, for a period of ninety-seven years) ; 'for it frequently happens while the farmers' horses are exposed to the cold rains which fall at this season, that their heels become diseased, and no cow-pox then appeared in the neighbourhood.' The disease, however, did appear the following year, viz., in 1798, a year in which small-pox in London was prevalent, there being 2,237 deaths.

Nobody at the present time would confidently look forward to the return of cow-pox in order to complete observations commenced the previous year. Concerning the rarity of the disease in 1840, Mr. Ceely, in discussing Dr. Sonderland's (of Bremen) article in the *Medical Gazette*,* November 9, 1831, says on page 94 of his work, 'Observations on the Variola

* See extract in *Medical Gazette*, November 9, 1831, taken from *Journal des Praktischen Heilkunde*, January, 1831.

Vaccinia': 'The result of careful and extensive inquiry induced the belief that the asserted comparative rarity of the disease was true as regarded this neighbourhood.' On page 47 he says: 'I am inclined to believe, from all the information I have been able to procure, that cow-pox is not so often met with as it was forty or fifty years ago; but upon this point I speak with much hesitation.' Mr. Ceely, be it remembered, was then writing at a time when cow-pox was more prevalent at Aylesbury than it had been for some years past, and than it has been since.

Horse-pox also seems liable to prevail during epidemics of small-pox. In the account of the disease at Rieumes in 1860, it is expressly stated that human small-pox was very prevalent at the time. (See Ballard Prize Essay, p. 32.)

Now, it appears likely, since small-pox and cow-pox are so similar—if not directly related—that the same conditions existing at certain times would be favourable to the spread of both diseases, and this might be given as a reason for the prevalence of the two together; but against this we may reasonably suppose that if it had not been for vaccination, epidemics of small-pox would have been more widely spread than they have been during this century (see Dr. Ballard's Prize Essay, p. 71 *et seq.*). But where, then, are the corresponding epidemics of cow-pox, which should have occurred if cow-pox be an independent disease? They also, together with the small-pox epidemics, have decreased. It has been urged that the milkers are now all vaccinated, and therefore are less likely to become affected with the natural disease, and therefore do not so readily convey the disease; but this cannot be the explanation, for the healthy hand seems to convey the disease from one animal to another quite as readily as the affected hand; besides, the disease must incapacitate those suffering from it from doing their work as milkers—at all events, for some time during its progress. This, however, is beyond the point, for it is not contended that the disease spreads less on a farm now than formerly, but that for years together it does not exist at all.

But besides the indirect evidence given above, there is positive evidence to bring forward to show that small-pox may be communicated by inoculation to horned cattle, and that the resulting vesicles yield lymph having all the properties of vaccine lymph. In other words, small-pox, by one transmission through an animal, becomes modified, so that it is not only no longer infectious, but also is limited as regards the eruption to the points of inoculation.

This, indeed, is not a unique experience in pathology, for in anthrax we have an analogous example. Anthrax, as is well known, is a very fatal and infectious disease among horned cattle. If a mouse is inoculated with the disease, as it may readily be, it dies; but if a healthy animal such as a sheep or ox be inoculated from the mouse, it produces a local sore on the sheep or ox which does not prove fatal, and subsequently protects it from the virulent form of the disease. Here the mouse in anthrax takes the place of the cow in small-pox. In both cases the virus is altered: from being virulent, it becomes benign.

Dr. Gassner,* of Gunzburg, so early as 1801, succeeded in inoculating a cow on the eleventh experiment with the small-pox virus, and used the lymph thus obtained for vaccinating four children, and from them seventeen others. No small-pox appeared among these children. In 1836, and again in 1838, Dr. Theile, of Kasan, succeeded in inoculating the cow with small-pox matter, and he used the lymph for the vaccination of children. He thus states his conclusions on this point:

'1st. The so-called vaccine is not an eruptive disease peculiar to the cow, but is produced in it by the transmission of human small-pox to it; and the man, and not the cow, as has hitherto been thought, is the source of the disease.

'2nd. The mild disease thus caused in the cow can, by direct transmission from the cow to man, produce in him

* Heine in Henke's *Zeitschr. Erganzungschrift*, xxx., p. 57; also *British and Foreign Medical Review*, January, 1840.

as mild a disease, which gives protection against the natural small-pox.'

His other conclusions refer to an artificial method of producing this modification in small-pox virus without the aid of the cow. This he thought he did by preserving small-pox virus for ten days between two pieces of glass, and then diluting it with milk, and using this mixture for vaccinating children. The lymph obtained from the resulting vesicles he again kept, and diluted with milk as before. After ten generations the lymph had become modified, and could be used without the addition of milk.* Mr. Ceely, in 1839, also succeeded in inoculating cows with small-pox, and found that the resulting lymph caused a disease identical with vaccinia. His experiments were published in the eighth volume of the Transactions of the Provincial Medical and Surgical Associations, and also in a separate work, entitled 'Observations on the Variola Vaccinia,' 1840, Worcester. In a note, on p. 140 of the latter, which is quoted to show that his experiments were independent of Dr. Theile's, he says: "But I am gratified to learn that since the announcement of those [experiments] which I have just detailed, intelligence has been received of the success of Dr. Basil Theile, of Kasan, in Russia, in similar experiments.'

He also, on the same page, states that when he wrote more than 2,000 subjects had been vaccinated with his variola vaccine lymph. About this time also Dr. Reiter, of Munich, succeeded. He had failed previously, but having adopted the method of inoculation practised by Dr. Theile, he succeeded.

In 1840, Mr. Badcock, then a chemist in Brighton, succeeded on his first attempt, and afterwards succeeded some thirty or forty times; nevertheless, his success only amounted to about 7 per cent. of his trials.† Some of the

* Henke's *Zeitschrift für die Staatsarzneikund*, 1839.

† 'Details of Experiments Proving the Identity of Cow-pox and Small-pox,' Brighton, 1845.

lymph thus obtained by Mr. Badcock furnished the stock which was used at the Highgate Small-pox and Vaccination Hospital for some fifteen years or more by Mr. Marson.

Dr. Vy,* of Elburg, in 1867, also succeeded, and used the lymph for vaccination. Most, if not all, experimenters who have succeeded agree that there is considerable difficulty in obtaining a characteristic pock on the cow from inoculation of small-pox; and, indeed, there are not a few who have entirely failed.

Mr. Marson tried forty times in succession without result. Coleman, King, Dalton, Sacco, Fiard, and Bousquet all failed; but M. Chauveau, and associated with him MM. Viennois and Meynet, who called papular tumefaction a success, succeeded every time, and from these papules they produced small-pox. Small-pox is also said to have resulted from experiments similar to those of M. Chauveau at Boston, U.S., and also at the Veterinary School of Berlin.†

In these experiments, however, there is no evidence to show that the original small-pox virus, with which the scratches were deluged, may not have been taken up again and used unchanged for the inoculation rather than the vaccination of children.

On November 18, 1885, Dr. Simpson, then of Aberdeen, sent me fifteen charge points to Lamb's Conduit Street, with the following history:

He had obtained some small-pox lymph from an unvaccinated female, F. P., aged 13, (a) on the fifth day of eruption, and (b) on the sixth day of eruption. On the eleventh he inoculated a cow with the small-pox lymph on one teat with one scarification from the lymph which had been taken on the fifth day of the girl's eruption, and on another teat with two scarifications from lymph of the sixth day of eruption.

* *Bulletin de l'Acad. de Med.*, t. xxxi., p. 430.

† See Seaton's 'Handbook of Vaccination,' p. 55.

On November 17, the seventh day afterwards, the single scarification yielded the fifteen points which were sent to Lamb's Conduit Street.

The two scarifications done with the sixth-day small-pox lymph only became papular.

The lymph on the fifteen points was used at Lamb's Conduit Street on November 21, 1885, for the inoculation of a male calf (938), aged about 6 months, in five incisions, three of which had taken, and were vesicular on November 26. From this calf, whose vaccine vesicles so exactly resembled the current vesicles, a child and another calf (941) were vaccinated, the child in five places, the calf in seventeen. The child was kept under observation, and it went through a course of normal vaccinia. No eruption occurred, and no small-pox was communicated to others. Calf 941 was successful in six out of the seventeen places it had been vaccinated in, and lymph was taken on December 1, *i.e.*, 120 hours after vaccination, for the vaccination of another child and another calf (994). The child was vaccinated by five separate insertions of the lymph, all of which were successful. This child also was kept under observation, and it went through a perfectly normal course of vaccination, and no small-pox was communicated to others. On December 5, ninety-six hours afterwards, two other calves were vaccinated from 994, and from this date to May 6, 1886, Simpson's lymph was regularly used at Lamb's Conduit Street, concurrently with the Bordeaux lymph, which was that ordinarily used at the station. During this time 1,247 children were vaccinated with it and seventy-nine calves. After the use of Simpson's lymph, out of the 1,247 children vaccinated with it, fifteen were brought back with some abnormality, or 1·2 per cent.; and after the use of the Bordeaux lymph, which was used concurrently with Simpson's, there were eight out of 685 children vaccinated with it brought back to the station for a like cause, or 1·16 per cent.

The writer's insertion success out of 1,174 cases was 98·4 per cent. with Simpson's, and with Bordeaux, out of 678

cases, it was 98·2 per cent. Simpson's lymph thus seemed a trifle more active than the Bordeaux.

No case of small-pox was heard of among the children, and no case of communication of small-pox to others.

The following synopsis of the origin and descent of Simpson's lymph may prove useful:

Date.	Synopsis of the Origin of Simpson's Lymph.
1885.	
Nov. 10	Small-pox virus obtained from F. P., a female, aged 13.
,, 11	
,, 11	Cow inoculated.
,, 17	15 points charge from the cow vaccinated on the 17th sent to Lamb's Conduit Street, from Aberdeen.
,, 21	Calf 938, aged 6 months, vaccinated.
,, 26	Child. Calf 941.
Dec. 1	Child. Calf 994.
,, 5	Calf 948. Calf 947.

From this date to May 6, 1886, Simpson's lymph was used regularly at Lamb's Conduit Street.

Lastly, the writer was associated with Dr. Klein, whose paper on the subject is published in the Supplement containing the Report of the Medical Officer of the Twenty-second Annual Report of the Local Government Board for 1892-93, in which photographs are reproduced, showing the vaccinated arms of the children. The following is a synopsis of a portion of his report:

SYNOPSIS OF DR. KLEIN'S REPORT.

Date.	Synopsis of the Origin of Klein's Lymph.
1892.	
May 31	Collected small-pox lymph* from (*a*) L. L., aged 13, unvaccinated, whose initial illness was on May 23 and had confluent small-pox May 25.
,, 31	(*b*) E. L., aged 32, vaccinated in infancy, initial illness May 20, confluent small-pox May 24. This lymph (from both cases) was inoculated at the Brown Institution into
,, 31	Calf 2.
June 4	Calf 4.
,, 9	6, transferred to Lamb's Conduit Street.
,, 13	8, young bull.
July 14	Scab from infant (L.).
,, 15	Calf 16, typical vaccinia.
,, 20	Points.
,, 20	Infant (L. S.), female. Infant (F. M. B.), female.

The three children who were vaccinated from this lymph series were closely watched, but the vaccination was perfectly normal.

It has been mentioned that the inoculation of small-pox on animals is a difficult matter, and only a few succeed. Such, however, is not the case when animals are vaccinated with current, *i.e.*, humanized lymph. This fact requires some consideration, because it can be urged in support of the view that small-pox and cow-pox are distinct diseases. We have seen that this difficulty is only in the transference of small-pox to the animal, and the probable reason is this, that the small-pox lymph is taken always from the general eruption of small-pox. To make it similar to vaccination the lymph should be taken on the eighth day from the mother

* The lymph was collected at the hospital ship.

vesicle of an inoculated human individual; but the law does not allow this in England.

Some have held that the cow-pox is sometimes infectious among horned cattle. Baron, in his 'Life of Jenner,' p. 234, says, 'I think there is good ground for believing that the disease as originally noted by Dr. Jenner was the epidemic or local remains of the more general or epizootic disease which prevailed in many parts of this island at the period when Dr. Layard wrote.'

He here refers to the epidemic described by Dr. Layard,* which occurred in 1745 to 1756, and again from 1760 to 1770. This epidemic Dr. Layard considered to be of the variolous kind. He says: 'It bears all the characteristics, symptoms, crises, and events of the small-pox, and, whether received by contagion or by inoculation, has the same appearances, stages, and determinations.' Yet his subsequent description of the disease is not altogether consistent with this statement. This opinion of the nature of the epidemic continued until 1865, in which year the cattle-plague made its appearance in England. It was soon recognised to be identical with the disease described by Layard, and its likeness to small-pox was again insisted upon by several, among whom was Dr. Murchison.

In the report of Dr. Murchison to the Privy Council, he gives this likeness as a reason to try the effect of vaccination on the disease; and again, writing to the *Times* after this had been tried and found of no avail, he says: 'The points of resemblance between cattle-plague and small-pox are so striking, that certain observers were led to hope that vaccination might protect,' etc.† The above quotation is sufficient to show that the cattle-plague did bear some resemblance to small-pox, but the following established points of difference will prove that they are not identical diseases, and are not any more related than scarlet fever is to measles:

* Philosophical Transactions for the year 1780.

† Letter of Dr. Murchison to the *Times*, January 30, 1866.

1st. The amount of the eruption in cattle-plague bears no relation to its fatality, which is certainly the case in the great majority of the cases of small-pox.

2nd. The eruption in the two diseases is anatomically different.

3rd. When cattle-plague is conveyed by inoculation from one animal to another there is no local development at the seat of inoculation, as occurs when small-pox is inoculated.

4th. Vaccination has been found to afford no protection against cattle-plague.

The epidemics of 1745 and 1760 must not any longer be regarded in any way as the small-pox among horned cattle.

The disease in India known as bussunt, mhata, or gotee,* is thus described by Mr. Lamb: 'The animals which were at first affected had been for a day or two previously dull and stupid. They were afterwards seized with cough, and much phlegm collected in their mouths and fauces. The animals had at this time no inclination for food. There is a discharge of saliva from the mouth, then follow universal tremor and great heat of the head, chest, and body, as far back as the loins, while the hindquarters are cold. The whole body then becomes hot, and the animals suffer from intense thirst. The mouth and fauces appear to be the principal seat of the disease, being in some instances one mass of ulceration. On the fifth day the eruption appears about the udder, sometimes only a few pustules, and at other times they are numerous and confluent; but the result of the attack does not appear to depend much on the eruption. Whether the pustules are numerous or rare, the disease is nearly always fatal, and unless measures are taken to separate the diseased from the healthy, it speedily runs throughout the whole herd, sparing few.

'In those who do escape after taking the infection the favourable symptom is a spontaneous diarrhœa, in which the dejections are large, watery, and offensive. Many die

* Transactions of the Medical and Physical Society of Calcutta, vol. viii.

before the eruption makes its appearance, but the fever is always known by the discharge of the saliva.'

Mr. Macpherson, Superintendent of Vaccination at Moorshedabad, tried inoculating this disease on children in 1832, hoping thereby to obtain a new stock of vaccine lymph, and he describes his experiments in the following words:* 'All the cattle in the neighbourhood became affected, and, amongst others, two belonging to one of my own vaccinators. I had them covered with blankets, leaving merely the udder and teats exposed to the air. On the seventh day two small pustules made their appearance on the teats of one, which died upon the tenth, and the crusts were removed on the twelfth day. From these crusts eleven native children were inoculated, one of them successfully. A vesicle appeared on the fifth day, which continued to increase till the ninth day, when it had all the characters of true vaccine; the child suffered much from fever for four days. Two children were vaccinated from this vesicle with complete success, the symptomatic fever being very severe. From these two children five others were successfully vaccinated, and the stock thus established was afterwards regularly continued. Some of the children vaccinated with the lymph were tested by variolous inoculation and exposure to variolous infection and found secure.'

Dr. Seaton, commenting upon the above related experiments, very justly remarks:† 'From these facts it is not to be doubted that a case of cow-pox in the cow had been met with; but what is to be doubted is that the gotee—the malignant disease above referred to — was the source of infection, for the eruption, so far from being like that said to be prevalent, viz., one of pustules all over the body, terminating in ulceration, was a couple of pustules (vesicles) only, having exactly the characters of an ordinary

* Transactions of the Medical and Physical Society of Calcutta, vol. vi., also Duncan Stewart's 'Report on Small-pox, Calcutta,' 1844, pp. 84 and 85.

† Seaton's 'Handbook of Vaccination,' p. 64.

case of casual cow-pox.' Dr. Duncan Stewart,* who reports this case, regrets that information was not given more fully regarding the appearance of the disease in the cows from which he took the crusts, one of which succeeded.

In 1833 Mr. Furnell,† a civil surgeon of Silhat, in Assam, having seen a report of Mr. Macpherson's experiments of the preceding year, determined to repeat them. He commenced by vaccinating four children with the scabs taken from the back of an animal suffering from gotee, but without effect. Having shortly afterwards to leave Silhat on account of his health, he asked Mr. David Brown, then Assistant-Surgeon of the Silhat Light Infantry, to continue the experiments. A reward was offered for an animal suffering from the disease, which was shortly obtained. Nothing, however, is said of the symptoms of the disease manifested by the animal, except that it was thin and out of condition. It appears, however, that it had a general eruption, for scabs were taken from the back of the animal and used for the vaccination of four children. All these vaccinations were successful. The resulting vesicles are said to have run a natural course, and from them four more children were vaccinated. Mr. Brown's‡ words are as follows: 'From this new virus vaccination was carefully propagated through successive numbers of children by either Mr. Furnell or myself, or the *native vaccinators* under our superintendence, through the months of October and November.' On November 23, 1833, Major Orchard's child and three native children were vaccinated from one child with this virus, and on December 1, *i.e.*, on the ninth day, Mr. Furnell vaccinated his own child from one of these native children. A day or two after this, in due time Major Orchard's child had severe small-pox, and the three native

* Stewart, *op. cit.*, p. 148.

† Transactions of the Medical and Physical Society of Calcutta, Appendix, vol. vii., p. 453, Mr. Furnell's account.

‡ *Op. cit.*, vol. viii., p. 97, Mr. Brown's account.

children all had slight but characteristic eruptions. Mr. Furnell's child, also, a week after this, had small-pox, of which it died on December 20. On making inquiries afterwards, Mr. Furnell ascertained that the native child from whom he had vaccinated Major Orchard's child and the three native children had had a general eruption after having been inspected. It could not, however, be ascertained how many of the native children vaccinated during October and November had suffered from small-pox, for no register was kept, and the children after vaccination were not again seen. Mr. Brown, apologizing for this, says: 'Why more children were not inspected was owing to no register having been kept.' And he goes on to say: 'In explanation of this apparent neglect I may state that the superintendence of vaccination on Mr. Furnell's part and my own was gratuitous, and not considered at the time as part of our duties.'

From the account of these last experiments of Mr. Furnell's and Mr. Brown's, it is not unjustifiable to regard them as of little or no scientific value:

(1) Because *native* vaccinators conducted some, if not most, of the vaccinations.*

(2) No description is given of the symptoms of the animal from whom the scabs were taken, save that it was thin and out of condition, and incidentally that it had a general eruption.

(3) No register was kept, Mr. Brown apologizing for the neglect on the ground that the work was gratuitous. So it might have been, but this neglect is unpardonable when it is remembered that their work was experimental, of which they intended to, and did, publish what results they could.

It is to be remarked that the disease known in India as bussunt, mhata, or gotee, as described by Mr. Lamb, bears so close a likeness to cattle-plague, that it seems reasonable

* The writer has been informed by a native medical man that many of the natives prefer inoculation with small-pox rather than vaccination.

to suppose that the disease which Mr. Furnell first witnessed was the cattle-plague, and that the see-saw vaccination (so-called) between Mr. Furnell and the native vaccinators became ultimately inoculation of small-pox.

It may also be observed that the experiments of Mr. Macpherson were made shortly after the publication of Dr. Baron's 'Life of Jenner,* who in Chapter V., p. 161, gives a most interesting and learned disquisition on the history of small-pox, but in which he regards small-pox and cattle-plague as identical diseases.

Such are the leading arguments and facts in favour of vaccinia being but a modified form of small-pox, and if true, then small-pox is the origin both of cow-pox, horse-pox, and camel-pox, and Jenner was most probably correct in his observations, but mistaken in their interpretation.

* This was published in 1827.

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