VACCINATION

Facts and Problems

Copy 1

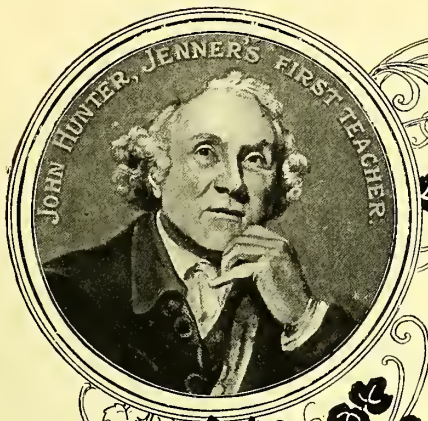
W. M. C. Wankling.

Room 337 A

New County Hall

S.E. 1

Hyp 5000



Vaccination

Facts and Problems.

London:
THE BRITISH MEDICAL ASSOCIATION, 429, STRAND.
1902.

Contents and Contributors

Introduction.

The issue of the British Medical Journal of July 5th, 1902, which is here reprinted, was devoted almost entirely to studies by writers of recognized authority of the more important problems—scientific, clinical, and administrative—connected with small-pox and vaccination. The number was issued in response to a wish expressed by many correspondents that we should reprint the "Jenner Centenary Number," which appeared on May 23rd, 1896. Since that date, however, the Royal Commission, after an inquiry extending over seven years, has reported, and as a consequence the Vaccination Act of 1898 has been passed, while the use of glycerinated calf lymph has become general. Further evidence of the necessity of revaccination has also been accumulated, notably in the epidemic which visited Glasgow in 1900-1902. In consideration of all these circumstances it was thought better to issue a complement to the "Jenner Number" rather than a mere reprint.

The account of Jenner's life and works with a number of portraits and illustrations of objects associated with the discoverer of vaccination was reproduced, but otherwise the contents of the number were wholly new. For records of the ravages of small-pox before Jenner showed us how to prevent it, of the introduction, practice, and abolition of inoculation, and of casual pre-Jennerian vaccinators, such as Jesty and Plett, reference should be made to the "Jenner Number." So large is the subject of vaccination that we found it impossible within the limits of space available to deal with every question connected with it, and we were therefore obliged to hold over a full abstract of the Report of the Royal Commission on Vaccination, which is now here published.

A brief review of the contents of the present number may be of assistance to the reader who may wish to study some special points without having to go through the vast mass of material here collected. The epidemiology of small-pox in the nineteenth century forms the subject of an elaborate study by Dr. Newsholme, who shows that the disease, like measles and whooping-cough, appears to become epidemic on a small scale at intervals of three or four years, and at longer intervals, which on two or three successive occasions have extended to thirty years, has become pandemic. Dr. Newsholme, however, holds that there is not sufficient evidence to justify the idea of a thirty years periodicity for small-pox. By means of a striking diagram we are enabled to see *oculis subjecta fidelibus* the rapid decline in the death-rate from small-pox which immediately followed the introduction of vaccination. Small-pox still recurs at intervals, although these intervals are a little longer than they formerly were, and the natural conditions for the production of the frequent devastating epidemics of past times still exist. The fact that such epidemics do not occur must therefore be due to the operation of a powerful inhibitory force. What is this force? The opponents of vaccination say it is the general improvement which has taken place in sanitary conditions. But apart from overcrowding there is absolutely no evidence of any connexion between bad sanitation and small-pox; and the fact that the death-rate from a disease which spreads like wildfire in an unprotected population has rapidly declined in spite of a vast increase of opportunities for its dissemination is of itself a striking testimony to the restraining force of a cause which can be nothing else than vaccination.

The mass of carefully sifted statistical evidence gathered by Dr. E. J. Edwardes is a powerful reinforcement of the facts set forth in Dr. Newsholme's paper. It proves conclusively the value of vaccination, but it is equally decisive as to the necessity of revaccination. It is this that has stamped out small-pox in Germany so thoroughly that the authors of the most authoritative German textbooks of diseases of children have not thought it necessary to give any description of the unmodified disease, which in that enlightened country is looked upon as outside the sphere of ordinary medical practice.

The case for revaccination is strengthened by the facts contained in Dr. A. K. Chalmers's report on the recent epidemic of small-pox in Glasgow, an abstract of which appears at p. 40. The figures given fully justify the statement there made that, as in Egypt, the Angel of Death passed by the houses of the Israelites whose doorposts were sprinkled with blood, so in Glasgow small-pox passed by those who submitted themselves to revaccination. What may be called the sanitary fallacy is dealt with in another article in which it is shown by a convincing array of facts that sanitation cannot account for the striking difference in liability to attack by small-pox in the vaccinated and unvaccinated respectively.

The present outbreak of small-pox in London brought to light the significant fact that medical practitioners of the present day had at first so little practical acquaintance with the appearance of the disease that mistakes in diagnosis occasionally occurred. The affection with which small-pox was most often confused was chicken-pox. The differential diagnosis of these two diseases is clearly set forth by Dr. McConnel Wanklyn, who from the abundance of clinical material at his disposal in the River Ambulance

Service of the Metropolitan Asylums Board has selected some typical cases, coloured drawings of which are reproduced. The bacteriology of vaccinia and variola is exhaustively discussed. The methods employed in the preparation of the glycerinated calf lymph at the vaccine establishments of the Local Government Board are described by Dr. Blaxall, and an account of the effects of vaccination with such lymph is given by Dr. A. E. Cope, late Honorary Secretary of the Association of Public Vaccinators. These effects are shown in four plates from coloured drawings, made by Mr. A. Engel Terzi, the artist who drew the coloured illustrations of Dr. Wanklyn's paper above referred to. In both cases the drawings were made from life and accurately pourtray the characteristic appearances.

Dr. Colcott Fox treats of the complications of vaccination —a subject of vital importance both in its scientific and its practical aspects. The recital of the various rashes and lesions which may follow vaccination, and the recognition of the possibility of inoculating syphilis, tuberculosis, and, theoretically, leprosy, may well cause alarm in ignorant minds, and these "complications" form, in fact, the stock-in-trade of the antivaccinationist. Practitioners will therefore welcome with satisfaction Dr. Fox's assurance that, allowing for some variation in the local and systemic effects due to the varying activity of the virus and the susceptibility of the subject, there are very few complications that it is not in our power to avert by using a pure lymph, conducting the operation in a proper manner and preventing any secondary contamination.

This brings us to the question of the supply of glycerinated calf lymph. The production of vaccine lymph should be in the hands of Government, or, if left in those of private makers, it should be under Government supervision. The fact that vaccination is carried out under the control of the State makes it the imperative duty of the State to see that the operation is safely as well as efficiently carried out. Mrs. Garrett Anderson gives a clear account of the complex administrative machinery by which the laws for the prevention of epidemic small-pox in this country are carried into effect. In the article on Vaccination Problems for Parliament a number of suggestions of great importance are made by Dr. J. C. McVail, whose views are based on a very extensive experience of the working of the existing laws. All the matters of which he treats will doubtless come under the serious consideration of the British Medical Association with a view to influencing public opinion and promoting legislation; and the article in question both clearly defines the questions to be discussed, and indicates the direction in which the solution of legislative problems that will soon become pressing may be sought.

Lastly, under the heading "Antivaccination Propaganda," the work of the Jenner Society, founded and successfully conducted by Dr. Bond, of Gloucester, is described, and an account of the origin of the antivaccination movement is given. The constitution and objects of the recently-established Imperial Vaccination League are also described. We hope before long to see these two bodies which are already spiritually united in a common cause materially combined in a strong organization which will actively oppose mischievous error and spread the light of truth in the dark places of ignorance and fanaticism.

In conclusion, we venture to express a hope that this special issue of the JOURNAL may prove useful to medical practitioners as a storehouse of facts, figures, and general information relating to the most efficient protective agency against a deadly disease which has yet been discovered.

Fig. 1.—Stereoscopic photograph of a case of small-pox by Dr. W. W. Stainthorpe (Saltburn).

Fig. 2.—Stereoscopic photograph of a case of small-pox by Dr. W. W. Stainthorpe (Saltburn).

BRITISH MEDICAL JOURNAL.

SPECIAL VACCINATION NUMBER.

LONDON: SATURDAY, JULY 5, 1902.

EDWARD JENNER:

HIS LIFE, HIS WORK, AND HIS WRITINGS.*

Early History.

Jenner vaccinating his own child." (From the Statue by Monteverde.)

EDWARD JENNER, the son of the Rev. Stephen Jenner, Rector of Rockhampton and Vicar of Berkeley, was born at the latter place, May 17th, 1749. His mother was daughter of the Rev. H. Head, a former vicar of Berkeley. His first school was at Wotton-under-Edge, where he was under the care of the Rev. Mr. Clissold; from there he was removed to the Rev. Dr. Washbourn, at Cirencester. Jenner's school career was of short duration. At about the age of 13 he began his professional education under Mr. Daniel Ludlow, of Sodbury; from there he entered as a student at St. George's Hospital, where his name appears in the list of students for 1770, and when he was 21 he went as house pupil to John Hunter. Jenner had an innate love of natural history, and nothing could have been more fortunate than his falling under influence such as Hunter's. The young pupil came with a fair knowledge of both zoology and geology; the fossiliferous rocks of his native county had given him ample opportunity for studying geology, and the collecting of fossils was a hobby which he retained throughout his life. To a young man with these tastes Hunter's house with its menagerie and collection of specimens must have been a paradise.

His Correspondence with John Hunter.

Between master and pupil an affection sprang up which was only terminated by Hunter's death. Unfortunately the letters from Jenner to Hunter have disappeared, but those of Hunter show that Jenner's opportunities in the country of getting specimens and carrying out experiments were always taken advantage of by Hunter and lovingly responded to by his pupil. These attentions of Jenner to Hunter were reciprocated by the latter making purchases for Jenner in town. "I have sent you the candlesticks as you desired," writes Hunter: "I hope you will like them. They cost five pounds and a shilling, so I owe you four shillings." Again, when Hewson's preparations were for sale, Hunter writes and offers to purchase any that Jenner may require. A subsequent letter shows that prices were too high for him to make any bargains. Hunter writes: "I could not buy a single preparation for you, they all went so dear—injections of the lymphatics of a turtle sold for guineas, an eye not injected fifteen shillings, and so of all the rest." In 1786 we read in one of Hunter's letters: "I have brought the print of Wright, viz., The Smiths, which is his best. There is one more I would have you have—I mean Sir Jos. Reynolds's of Count Hugolino (*sic*); it is most admirable, and fit only for a man of taste."

Jenner frequently asked Hunter's advice in professional matters, and also sent patients up to London to him. Hunter's replies to Jenner's queries were generally mixed up with requests for specimens or for experiments. In 1776 he writes: "I have but one order to send you, which is send everything you can get, either animal, vegetable, or mineral, and the compound of the two, viz., either animal or vegetable mineralized. I would have you do nothing with the Boy but dress him superficially; these Fungus's will die, and be damnd to them, and drop off. Have you large trees of different kinds that you can make free with?" Hunter offered him a share in the school of natural history which he purposed starting. Jenner refused this offer; Hunter's reply to the refusal is given in facsimile on pages 11 and 12.

His love for natural history nearly robbed medical science of Jenner's discovery. He arranged and prepared the specimens brought home by Captain Cook in 1771, and was offered the post of naturalist to the next expedition, which sailed in the following year. This, however, he declined, and settled down into country practice at his native town of Berkeley. Here for some years he led the quiet life of a country doctor, with ample leisure for his natural history pursuits. Baron, in his *Life*, gives us a picture of Jenner from the pen of his great friend, Edward Gardner, of Frampton:

"His height was rather under the middle size, his person was robust but active and well formed. In his dress he was peculiarly neat and everything about him showed the man intent and serious and well prepared to meet the duties of his calling.

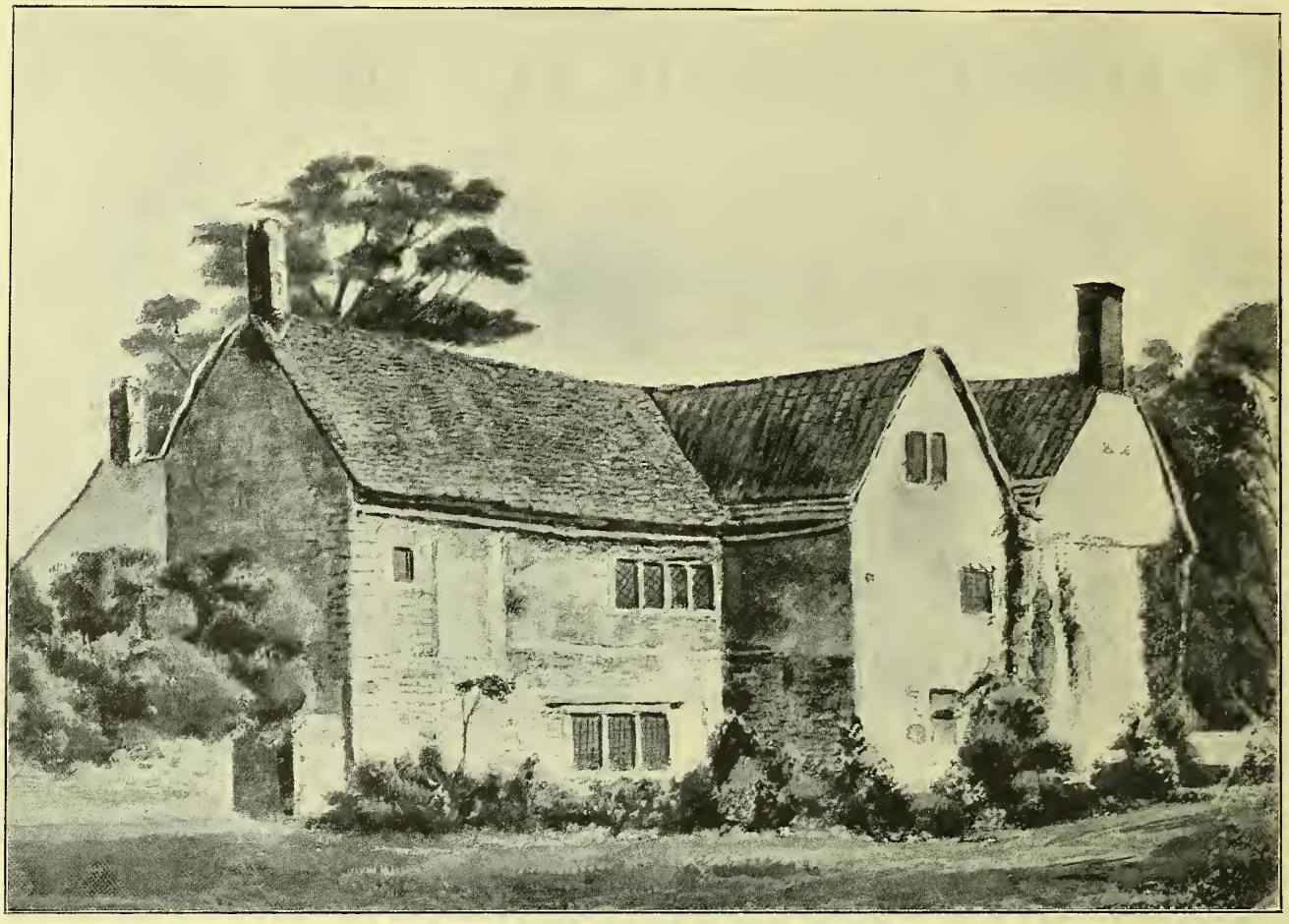
"When I first saw him it was on Frampton Green. I was somewhat his junior in years, and had heard so much of Mr. Jenner, of Berkeley, that I had no small curiosity to see him. He was dressed in a blue coat, and yellow buttons, buckskins, well-polished jockey boots with handsome silver spurs, and he carried a smart whip with a silver handle. His hair, after the fashion of the times, was done up in a club, and he wore a broad-brimmed hat."

Baron's own description of his first interview with Jenner is as follows:

"The simple dignity of his aspect, the kind and familiar tone of his language, and the perfect sincerity and good faith manifested in all he said and did could not fail to win the heart of any one not insensible to such qualities.....He was dressed in a blue coat, white waistcoat, nankeen breeches, and white stockings. We are grateful to him who told us that Milton wore large buckles and that Washington broke in his own horses, and in some future day the curious reader may be thankful for such particulars descriptive of the habits of Jenner."

It is from such contemporary descriptions only that pictures of the great men of the past can be completed; for this reason it is worth quoting a paragraph from the obituary notice of Jenner in the *Gentleman's Magazine*, xciii, 104, evidently written by some one acquainted with him:

* Reprinted from the Jenner Centenary Number of the British Medical Journal, May 23rd, 1896.



The Old Vicarage at Berkeley where Jenner was born.

"In his housekeeping nothing was gaudy but all was good. The cookery was tastefully and fashionably set out, the wines commonly five or six kinds, old and of fine flavour. At a striking innocent trait of character the philosopher, as a keen observer, would smile cheerfully, but the writer of this never saw him indulge in what is called a horse laugh."

In 1778 Jenner was crossed in love; this he took very much to heart, and probably his correspondence with Hunter did not improve matters. Although not such a misogynist as his brother William, yet John had not very tender feelings towards the fair sex. He had evidently heard a false report as regards Jenner, for, with his usual disregard of grammar and spelling, he writes: "I was told the other day that you was married, and to a young lady with a considerable fortune. I hope it is true, for I do not know anybody more deserving of one." On hearing the truth, Hunter writes again: "I own I was at a loss to account for your silence, and I am sorry at the cause. I can easily conceive how you must feel, for you have two passions to cope with, namely, that of being disappointed in love, and that of being defeted; but both will wear out, perhaps the first soonest. I own I was glad when I heard you was married to a woman of fortune; but 'let her go, never mind her.' I shall imploy you with Hedge Hogs, for I do not know how far I may trust mine." There seems a continuous line of thought here, Jenner's future mistrust of the fair sex and Hunter's present mistrust of his hedgehogs.

Family Life at Berkeley.

In 1788 Jenner was married to Miss Catharine Kingscote; although Mrs. Jenner was in delicate health she was able to do much for the poor and suffering in her neighbourhood. In this she was efficiently helped by her husband. Jenner took an active part in all local work; he was a Justice of the Peace for the County of Gloucester, and performed the duties attaching to this office with great assiduity; in fact, Jenner's brother justices seem to have left a large part of the work to him; he also filled the office of mayor of Berkeley. In Rudder's *History of Gloucestershire* it is stated that Berkeley "is called a borough, though it sends no members to Parliament, and has a mayor annually chosen at the court-leet, who has the tolls of the town and wheelage of all goods landed from the vessels in the river at 2d. a load; but the authority and privilege of his office seem to extend no further."

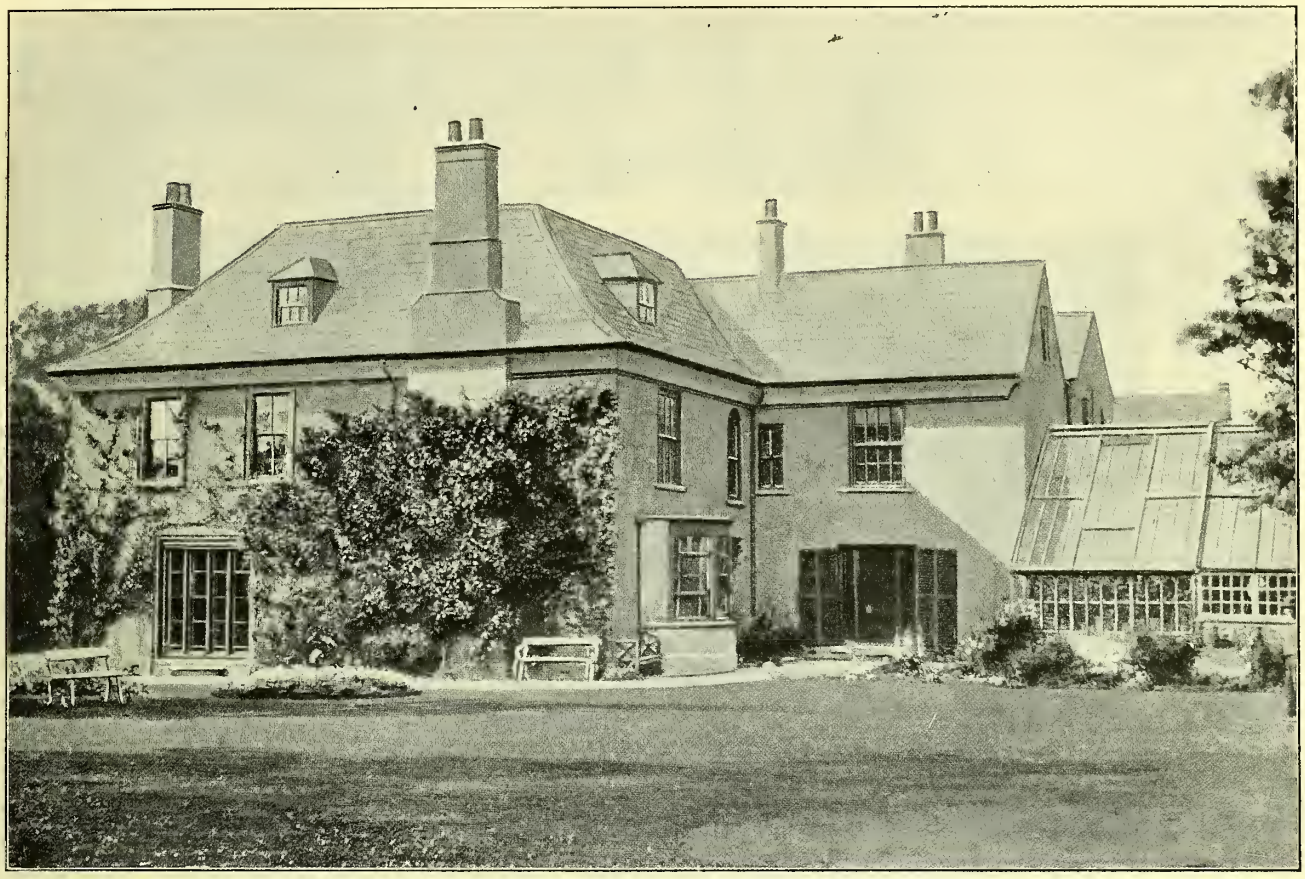
Jenner vaccinated all the poor in his neighbourhood gratuitously; for this purpose he had a special place erected in his garden, which he called the Temple of Vaccina. From one parish, however, he had for a long time but very few patients; all at once, from this same parish, people came in great numbers. On his making inquiry as to this sudden wish for vaccination, he was told that the churchwardens had been urging the people to be vaccinated on account of the great cost to the parish of the increased number of coffins due to deaths from small-pox!

There were three children born to Jenner—Edward, Catherine, and Robert. John Hunter stood godfather to the eldest boy. The following is his reply to Jenner's request that he would undertake this office:

January, 1789.

Dear Jenner,—I wish you joy; it never rains but it pours. Rather than the brat should not be a Christian I will stand godfather, for I should be unhappy if the poor little thing should go to the devil because I would not stand godfather. I hope Mrs. Jenner is well, and that you begin to look grave now that you are a father.—Yours sincerely,

John Hunter.



Vicarage at Berkeley showing window of room in which Jenner died.

Edward was very delicate, and for his tuition at home Jenner engaged the services of a remarkable youth, John Dawes Worgan; he was a lad of great promise, and was preparing to go to Oxford with the view of being ordained. This he was unable to do on account of weak health, and he died in 1809 at the age of 19. A volume of his poems was published in 1810, with a preface by William Hayley. The book was dedicated to Jenner, and in the preface he is thus referred to: "To you, who animated the exertions of Worgan's life by your approbation, and who watched over the couch of his affliction with the skill and sympathy of an affectionate physician, these his remains must be particularly interesting." Though Worgan died so young he wrote some essays in the *Gentleman's Magazine* in defence of vaccination over the signature "Cosmopolitus."

Retirement from General Practice.

In 1792 Jenner obtained the degree of M.D. from St. Andrews, and gave up general practice. This degree was obtained upon the recommendation of his friends Dr. Hickes of Gloucester and Dr. Parry of Bath. The entry in the minute book of the Senatus Academicus is dated July 8th, 1792; Jenner's name is wrongly written in the minute book, as the entry reads: "The University agree to confer the Degree of Doctor in Medicine on Mr. Edward Jennings, Surgeon of Berkeley, in the county of Glocester, upon recommendation from J. H. Hickes, M.D., of Gloster, and C. H. Parry, M.D., of Bath." In the Roll of Graduates the name was originally entered as Jennings, but has been subsequently altered to Jenner.

Accidents and Illnesses.

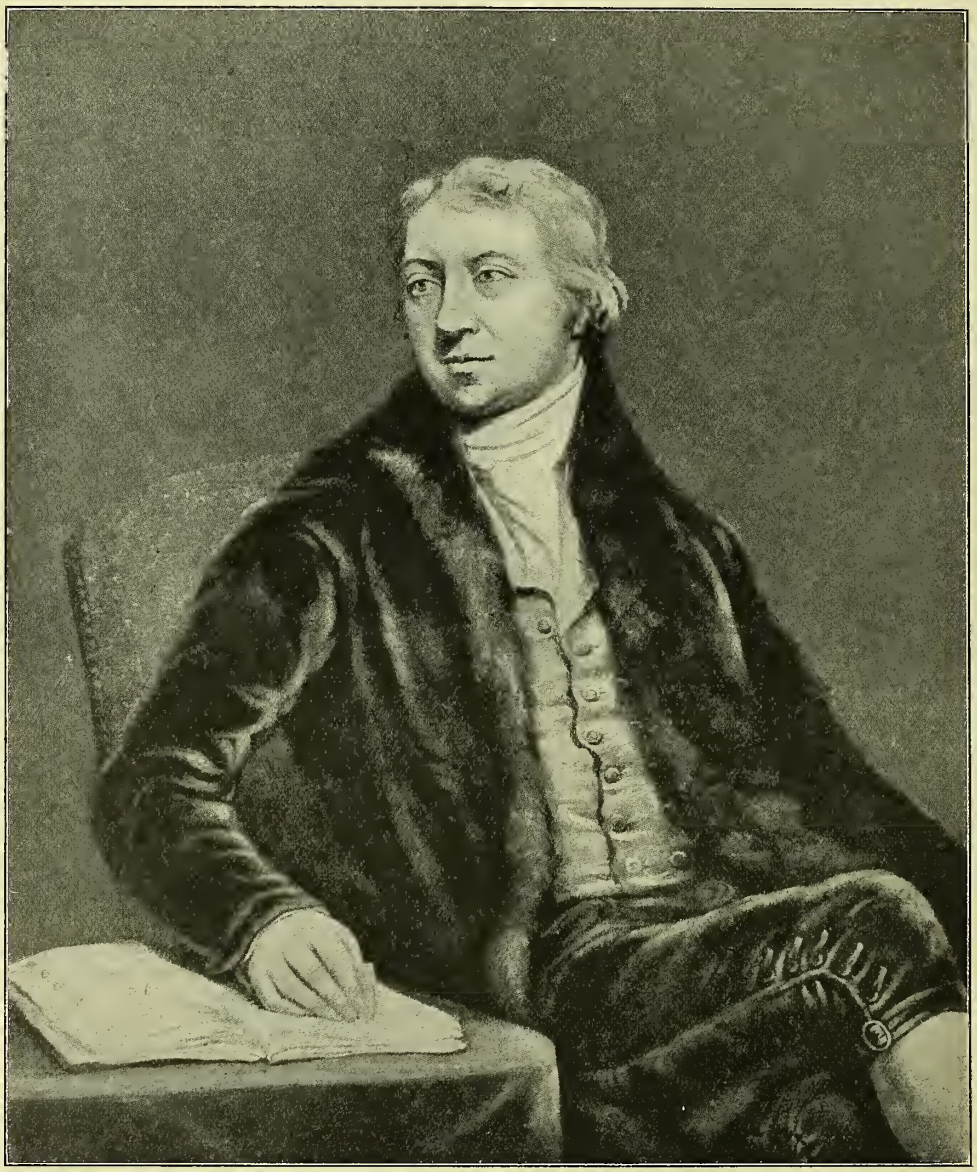
Three times Jenner had a very narrow escape of losing his life. The first was during the severe frost of 1786. He had to ride from Berkeley to Kingscote on an intensely cold day in a blinding snowstorm. The experience is worth recording in Jenner's own words: "As the sense of external cold increased, the heat about the stomach seemed to increase. I had the same sensation as if I had drank a considerable quantity of wine or brandy; and my spirits rose in proportion to this sensation. I felt, as it were, like one intoxicated, and could not forbear singing, etc. My hands at last grew extremely painful, and this distressed my spirits in some degree. When I came to the house I was unable to dismount without assistance. I was almost senseless, but I had just recollection and power enough left to prevent the servants from bringing me to a fire. I was carried to the stable first, and from thence was gradually introduced to a warmer atmosphere. I could bear no greater heat than that of the stable for some time. Rubbing my hands in snow took off the pain very quickly. The parts which had been most benumbed felt for some time afterwards as if they had been slightly burnt. My horse lost part of the cuticle and hair at the upper part of the neck, and also from his ears. I had not the least inclination to take wine or any kind of refreshment. One man perished a few miles from Kingscote at the same time and from the same cause."

In 1794 he had a severe attack of typhus, contracted whilst attending his nephew Henry's wife, and again in 1811 he was stricken down with the same disease.

Jenner's home life at Berkeley for many years was one of great happiness. This was afterwards much clouded by the illness of his son, Edward, which terminated fatally in 1810. Mrs. Jenner, too, was very delicate: the state of her health caused Jenner great anxiety for some considerable time before her death, which took place at Cheltenham, September 13th, 1815. Jenner had taken up his abode at the last-named place about five years previous to his wife's death. Immediately after this sad event he again went back to Berkeley, and, except for a day or two, never left his native place again.

The marriage of his daughter Catherine in 1822 left Jenner still more desolate. This lady died August 5th, 1833, having given birth to a daughter four days previously. His other son, Captain Robert Fitzharding Jenner, also survived his father.

In 1820 Jenner had a fainting fit in his garden. He was picked up insensible and carried to his house. Baron was at once summoned, and on his arrival found that his patient had rallied, and that there was no reason for apprehending immediate danger. From this attack he never thoroughly recovered. The state of his feelings is best described in his own words, which are quoted from a letter written to Baron, May 31st, 1821. The original is in the Library of the Royal College of Surgeons. "My nerves still vibrate too readily when touched by unnatural sounds. Nature built the brain and nerves, but glasses, plates, knives, forks, and spoons are not of her manufactory. The sharp sounds elicited by the sudden contact of these bodies when forcibly brought together produce an effect like the splash from a stone, forcibly thrown into a pool of smooth water. The propensity to feel this and the violence of the shock is in proportion to the length of the interval between one shock and another. Hollow sounds, such as church bells at a due distance, I do not regard, nor the rumbling of a waggon, however near, nor thunder. The clatter of a dinner table is the worst of all, from the clickings of knives, forks, and spoons on earthen plates; and it is more annoying when there are only two or three at table than when there is a party—perhaps from my attention being more abstracted from myself."



From an engraving by W. Say of a picture by J. Northcote (1823).

Death and Burial.

On January 24th, 1823, Jenner saw a patient whom he describes as being in "a state of paralytic debility." On the following day he himself was found insensible on a couch, in a like condition to the last patient he ever visited. Again his old friend Baron was sent for, but this time without avail, and Jenner breathed his last on the following day. On February 3rd he was laid to rest in the chancel of Berkeley Church, by the side of his beloved wife.

The vicarage at Berkeley, where Jenner was born, is no longer in existence. The illustration of his birthplace is taken from a painting in the possession of Mr. F. Mockler. The room in which he died is that with glass door and Venetian shutters next to the conservatory in the picture of the present vicarage (p. 3), which was partly erected on the site of "The Chantry." The "Temple of Vaccinia" is still standing, and is figured on p. 14. The hide of the cow from which Jenner took the matter to inoculate Sarah Nelmes is now in the curator's room at St. George's Hospital; an inscription states that it was presented to the hospital on October 14th, 1857, by Jenner's son.

Discovery of Vaccination.

The year 1796 is a memorable one in Jenner's history, as on May 14th in that year he performed his first inoculation with cow-pox. The subject was a boy, about 8 years old, named James Phipps, and the matter was taken from the hand of Sarah Nelmes, a dairymaid who had become infected by her master's cows. This was an anxious time for Jenner. On July 1st variolous matter taken directly from a pustule was inserted, but no disease followed. At once he writes off to his friend Gardner to tell him of his success. After describing the inoculation he proceeds:

"Having never seen the disease but in its casual way before—that is, when communicated from the cow to the

hand off the milker—I was astonished at the close resemblance of the pustules in some of their stages to the variolous pustules. But now listen to the most delightful part of my story: The boy has since been inoculated for the small-pox, which, as I ventured to predict, produced no effect. I shall now pursue my experiments with redoubled ardour."

This subject seems to have first attracted Jenner's attention when he was a pupil at Sodbury. A young girl came there for advice, and on small-pox being mentioned she exclaimed: "I cannot take that disease for I have had cow-pox." During Jenner's pupilage he mentioned this matter to Hunter, who does not seem to have been much struck with the idea, but he gave to his pupil one good bit of advice, "Do not think, but try; be patient, be accurate." On his return to Berkeley the idea was ever constant in his mind. He found that the opinion of the young girl at Sodbury was a general one amongst the milkers in and around Berkeley. To get at the truth of this opinion was his great object, but it was not until 1780 that he felt sufficient confidence in his conclusions to warrant his imparting them to others. It was to Gardner that he first made known his ideas on the subject of propagating the protective cow-pox from one individual to another, and so ultimately staying the plague of small-pox. "Gardner," said Jenner, "I have entrusted a most important matter to you, which I firmly believe will prove of essential benefit to the human race. I know you, and should not wish what I have stated to be brought into conversation, for should anything untoward turn up in my experiments I should be made, particularly by my medical brethren, the subject of ridicule, for I am the mark they all shoot at." In 1788 he brought the question under the notice of the profession in London, but he does not seem to have made much impression on any one but Henry Cline. The period between this and 1796 was spent in experimental inquiries, and on May 14th in that year, as before stated, he carried out his first inoculation with the cow-pox. Then for two years there was no material for further experiments, as cow-pox disappeared from the dairies in his neighbourhood. The publication of the *Inquiry* in 1798 is referred to in the article on Jenner's works (p. 10).

Statue in Kensington Gardens by Mr. W. Calder Marshall, R.A.

Just before the issue of the *Inquiry* Jenner went again to London, where he stayed for nearly three months; but to his great mortification, he was unable to find one person on whom he could show the benefit of vaccine inoculation. Cline, however, in August of the same year inoculated a child, and he writes to Jenner: "The cow-pox experiment has succeeded admirably. The child sickened on the seventh day; and the fever, which was moderate, subsided on the eleventh day.....I have since inoculated him with small-pox matter in three places, which were slightly inflamed on the third day, and then subsided." Cline, satisfied with the truth of Jenner's discovery, tried to persuade him to leave Berkeley and settle down in London, and assured him of a large and lucrative practice if he would do so. Jenner was proof against this tempting offer, and decided to remain in the country. Later he did give in to the advice of his friends, and took No. 14, Hertford Street, Mayfair, on a lease for ten years; he found, however, that the expenses of a London house were not compensated for by the practice he obtained, and so gave it up before the expiration of his lease and returned to Berkeley, going up to London occasionally as business required his presence there.

The spread of vaccination at home and in foreign countries

is dealt with in another article. Here it may be noticed that though honours fell thickly upon him at home his reputation was still greater abroad. On more than one occasion he was the means of obtaining the release of Englishmen detained in captivity abroad. With Napoleon he was a great favourite; on one occasion Jenner petitioned him to allow two friends to return to England; Napoleon was about to refuse the petition when Josephine reminded him that it was from Jenner. "Ah," said the Emperor, "Jenner, we can refuse nothing to that man." So great was his influence that a document signed by him was a good passport; Baron has preserved one of these for us. It runs as follows: "I hereby certify that Mr. A., the young gentleman who is the bearer of this, and who is about to sail from the port of Bristol on board the *Adventure*, Captain Vesey, for the island of Madeira, has no other object in view than the recovery of his health.—Edward Jenner, Member of the N.I. of France, etc., Berkeley, Gloucestershire, July 1st, 1810."

The principal honours awarded to Jenner at home and abroad will be found in a tabulated form at the end of this paper.

From a portrait by J. Northcote, R.A. (1803), now in the National Portrait Gallery.

Attacks on the Discovery and the Discoverer.

It was hardly to be expected that so great an advance in protective medicine could be made without opposition. Misstatement and misrepresentation Jenner had to put up with and combat. The caricaturists of the period were not slow to take the matter up; in many of these persons are drawn with horns and cows' heads growing from their heads as the result of vaccination. Nor was such grotesque falsehood limited to the caricaturists. Dr. Rowley published a tract called "Cow-pox Inoculation no Security against Small-pox Infection;" in this he figured an ox-faced boy, the fact being gravely stated that this appearance was due to the young man having been vaccinated. Dr. Benjamin Moseley, too, was a most determined opponent of vaccination, and lost no opportunity of attacking it. Cases were published where small-pox had undoubtedly followed vaccination. These Jenner had anticipated. "I expect," he said, "that cases of this sort will flow in upon me in no inconsiderable numbers; and for this plain reason—a great number, perhaps the majority, of those who inoculate are not sufficiently acquainted with the nature of the disease to enable them to discriminate with due accuracy between the perfect and imperfect pustule. This is a lesson not very difficult to learn, but unless it is learnt, to inoculate the cow-pox is folly and presumption." Another cause of the so called failures was the want of care in those who performed the vaccinations. Jenner investigated many of the cases, and found that small-pox matter had been inserted into the arm on the third and fifth days after vaccination. Some of the cases, too, had been vaccinated in the variolous atmosphere of the Small-pox Hospital. This institution was founded in 1746 for the purposes of isolation and for inoculating the poor; long after the benefits of vaccination had been clearly shown, small-pox inoculation was practised at this hospital.

It was hardly to be expected that Jenner's discovery would escape the *odium theologicum*; many sermons were preached to show the wickedness of vaccination, and one preacher went so far as to try to demonstrate that the cow-pox inoculation was Antichrist.

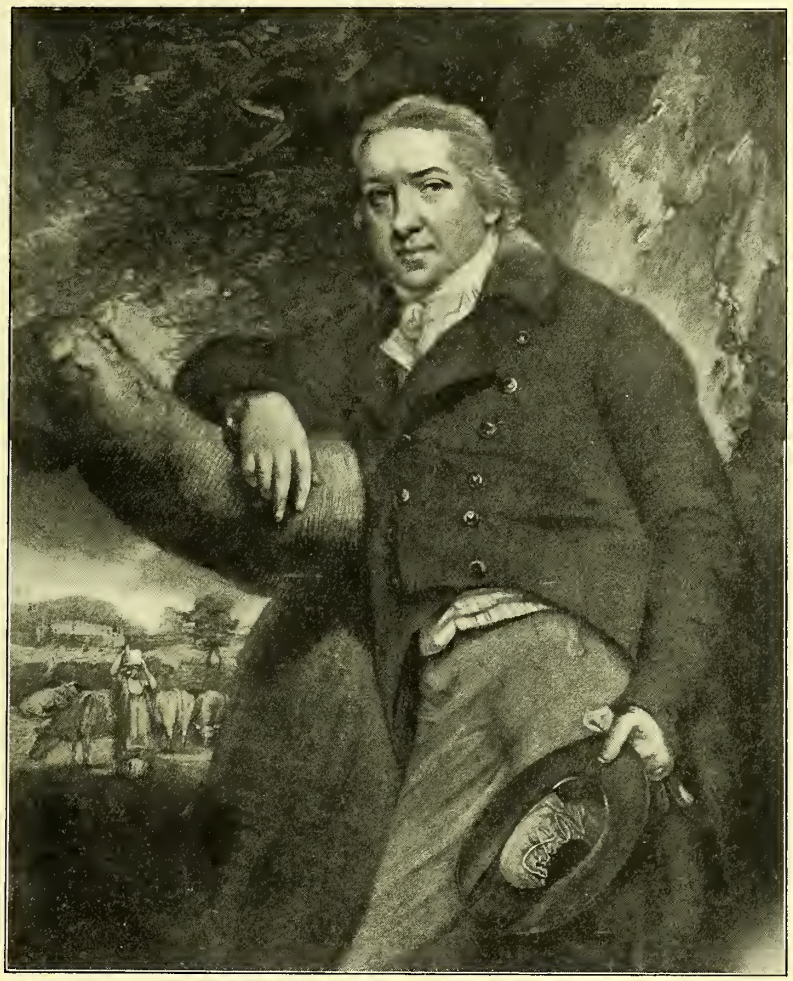
Grants to Jenner by the House of Commons.

On March 17th, 1802, Jenner presented a petition to the House of Commons. In this he drew attention to what he had done almost single-handed for vaccination, and asked the House to grant him such remuneration as in their wisdom should seem meet. Stress was laid upon the fact that the new discovery was made known to all, and that the author of it, instead of reaping any pecuniary benefit, had been put to considerable expense. The petition was referred to a Committee of the House under the chairmanship of Admiral Berkeley. The three heads of inquiry were: (1) The utility of the discovery itself, which is the foundation of the petition; (2) the right of the petitioner to claim the discovery; (3) the advantage, in point of medical practice and pecuniary emolument, which he has derived from it. The Committee sat from March 22nd until April 26th, and examined forty-five witnesses, including all the chief practitioners of the day. The Report of the Committee on the three points submitted to them was: (1) The result is that the discovery of vaccine inoculation is of the most general utility; (2) the whole of the oral depositions, as well as all the written documents from abroad, are uniform and decisive in favour of Dr. Jenner's claim to originality in the discovery; (3) he has not only reaped no advantage from his discovery, but he has been a considerable loser by the persevering attention which he has bestowed upon this one subject to the neglect of his other business..... What his gain might probably have been if he had been solicitous to keep the secret within his own practice and that of his immediate pupils, as far as medical men in great practice themselves can form a conjectural opinion, may be collected from the testimonies expressed in Nos. 7 (Dr. Bradley) and 30 (Dr. Baillie), in which no more than justice is done to the liberality and public spirit of the petitioner in pursuing the propagation and extension of this important discovery, and in rendering it

rather of universal utility to the human race than of emolument to himself.

Dr. Bradley stated that Jenner might have expected, if he had settled in town and kept this secret to himself, £10,000 a-year at the present time [1802] and £20,000 within five years. Dr. Baillie told the Committee that Jenner "might have acquired a considerable fortune." It was pointed out that not only had he suffered loss in the way mentioned by Dr. Bradley, but that he had been put to great out-of-pocket expenses. His postages, home and foreign, came frequently to over £1 a-day. So great was the call on Jenner's time and pocket by those who, in all parts of the world, were anxious to obtain information about the discovery, that he dubbed himself "Vaccine Clerk to the World."

In June, 1802, a debate arose in the House of Commons on the report of the Committee. Admiral Berkeley, the Chairman of the Committee, explained portions of the report, and proposed that a grant of £10,000 should be made to Jenner. He stated that personally he thought the amount too small, and he should leave himself quite open to vote for a larger amount if an amendment to that effect were submitted to the House. The gallant Admiral put the matter in a plain, business-like form, to show the moderation of his proposal. There was plain evidence, he said, that Jenner had been the means of saving 40,000 lives per annum in the United Kingdom only; taking each life as worth only 10s., there was due to Jenner £20,000 per annum. Sir Henry Mildmay thought the sum proposed quite inadequate, and moved that £20,000 be inserted in place of £10,000. Mr. Bankes opposed the grant on economical grounds; he acknowledged the utility and general benefit of the discovery, but thought that Jenner had it in his power to remunerate himself by practising vaccination. In his opinion, Jenner had made a mistake in imparting the secret to the public. Mr. Windham answered the objections of Mr. Bankes; and Sir James Sinclair Erskine pointed out that Jenner had come to London at great cost to render his discovery more useful, and that he had sacrificed his practice at Berkeley for this purpose. The Chancellor of the Exchequer said that whatever sum was voted to Jenner, one thing was clear, namely, that he had already received the greatest reward that any individual could receive—the unanimous approval of the House of Commons. The right hon. gentleman pointed out that no money value could be put upon the discovery, as it was beyond all calculation. The difference between £10,000 and £20,000 was not the standard by which the Committee of the House judged of the merit of Dr. Jenner, but the question of the amount had a reference to the duty which they owed to the public. The Chancellor thought that the vote would largely increase Jenner's practice, and that he would be thus indirectly benefited. To this Mr. Grey replied that there was no reason to expect such a consequence when everything attending the vaccine inoculation had been rendered so easy by Dr. Jenner's generous conduct. After Mr. Wilberforce and Mr. Courtenay had spoken both in praise of Jenner, a vote was taken by which it was decided that the grant should be £10,000. The numbers were: For the retention of the words ten thousand pounds, 59; against, 56; majority, 3.



From an engraving by J. R. Smith.

On July 29th, 1807, the question of giving recompense to Jenner was again brought before the House of Commons by the Right Hon. Spencer Perceval (Chancellor of the Exchequer), who proposed that a second grant of £10,000 be paid to the discoverer of vaccination. In doing this Mr. Perceval referred to the previous grant, and pointed out that the intervening time had strengthened the general opinion as to the efficacy of vaccination and as to its great benefit to the nation at large. Mr. Shaw Lefevre stated the case of the antivaccinists; his main argument was that cases had been reported which were not successful. He, however, added: "I certainly shall oppose this vote; at the same time I ought to add that I do not know that I shall always persist in opposing it, for that my great object is to gain time and further opportunity to examine the report of the Royal College of Physicians." A long debate ensued, in the course of which Mr. Edward Morris, M.P. for Newport (Cornwall), moved that £20,000 be substituted for £10,000. The reason given by Mr. Morris for his amendment was that "during the progress, thus judiciously withheld for a great number of years, it is almost impossible that he (Jenner) could have followed the ordinary duties of his profession; he must have sacrificed a great portion of his practice as a physician, so that the time which he devoted to the discovery of this inestimable remedy may be said to be time devoted to the interest of the public, and entirely at his own risk." Mr. Wilberforce stated that on the previous occasion he had voted for the smaller sum, but "that was at a much earlier period of the discovery than the present." Instead of giving Jenner either £10,000 or £20,000, he was in favour of granting £1,000 per annum, "because it looks more like a memorial of the affection and gratitude of his country, and more likely to point him out as a person possessing and enjoying the affection and gratitude of his countrymen, who entertain a proper sense of the benefits they have received from him." It was

pointed out that as the House was in Committee of Supply it could do no more than vote the supplies for the year, so that Mr. Wilberforce's proposal could not be adopted. The Chancellor of the Exchequer spoke in favour of the smaller amount, but the grant of £20,000 was carried by a majority of 13.

In looking at the small majorities by which these votes were carried, it must be borne in mind that the question on each occasion was not whether a grant should be made to Jenner or not, but whether the amount should be £10,000 or £20,000. Had the former question been the one before the House, it would have been carried with scarcely a dissentient voice. No truer estimate of the high opinion which educated men held of Jenner's character can be obtained than that which is evident in reading the reports of both of these debates. Even where a speaker disagrees with the vote, or has doubts as to the efficacy of vaccination, there is not a word to be found derogatory to Jenner's good name. No better evidence of this unanimity can be given than that of Dr. Moseley, who was Jenner's most bitter opponent. In his anger he writes: "It will not be credited by future generations that both these large sums were granted by Parliament without even a symptom of controversial discussion. Party tongues were dumb, and the spirits of contention, which on subjects of much less importance to the human race have so often shaken the empire, were here absorbed in sympathetic composure and unity."

Official red tape was well illustrated in the payment of the first grant; there was considerable delay in handing over the money to Jenner, and when this was done nearly £1,000 was deducted for fees and costs. To some extent this was remedied in the second grant, as the resolution of the Committee distinctly stated that the amount was to be paid "without any fee or other reward whatever."

From the painting by Sir Thomas Lawrence in the possession of the Royal College of Physicians.

Jenner's Personal Character.

In forming an estimate of any public man's character there is generally a *via media* lying between the too enthusiastic praise of well-meaning but perhaps not always strictly unprejudiced personal friends and the bitter malice of opponents. In very few instances is this more a fact than it is in Jenner's case. Baron was so great a worshipper of Jenner that his statements are sometimes warped by his affection for his friend. On the other hand, those who are opposed to vaccination, and cannot or will not see the benefits which the human race has derived from it, can hardly find words hard enough to express their contempt for Jenner.

That he was a great man of the stamp of John and William Hunter probably no one would assert. But he was a patient observer with a great love of Nature; probably dilatory and unmethodical: Baron's picture of him with his fossils scattered about rather points to this.

Of Jenner's manual dexterity Hunter evidently had not a very high opinion. To carry out some experiments for Hunter, Jenner had asked for a thermometer; the former sent the instrument, but in his letter says: "You very modestly ask for a thermometer; I will send you one, but take care that those damnd clumsy fingers do not break it also."

His perseverance with his investigations as regards the cow-pox is plainly shown; in season and out of season he talks of it to his friends. So much so was this the case at the local societies to which Jenner belonged that he was, by his fellow members, looked upon as having a bee in his bonnet, and it was intimated to him that a little less about his theory would be very acceptable. But in Baron and Gardner he had friends who did not tire and who urged him on in his work by their sympathy.

As a friend and companion he was evidently much appreciated by his neighbours at Berkeley; in all local affairs he took great interest, and his time for this purpose was, so far as his professional duties would permit, always freely at the disposal of his fellow townsmen.

Jenner was a man with a deeply religious mind; in this he was undoubtedly greatly influenced by the example of his wife. Some of his last words were: "I do not marvel that men are not grateful to me, but I am surprised that they do not feel gratitude to God for making me a medium of good." His very last public act was to attend a meeting at Berkeley for forming a Bible Society; at this meeting he moved the chief resolution.

Jenner's ideal of professional honour was certainly greater than that of some of his contemporaries. When he had written out the account of his improved mode of preparing tartar emetic, Hunter writes off at once and suggests that Jenner should give the preparation a new name, and he adds: "I would have you to burn your book, for you will have all the world making it." Jenner was proof against this temptation to reap reward from the use of a secret remedy, and published his paper in the *Transactions of the Society for the Improvement of Medical and Chirurgical Knowledge*. It was also pointed out by persons very competent to express an opinion on the subject that Jenner might have reaped a rich harvest had he kept secret his method of vaccination. Benjamin Travers, writing in 1804, says: "You should not have acted

in the manner you have; your liberality and disinterestedness every one must admire and extol, but you are sadly deficient in worldly wisdom." Again he writes: "If you had undertaken the extinction of the small-pox yourself, with coadjutors of your own appointment, I am confident you might have put £100,000 in your pocket, and the glory be as great and the benefit to the community the same." As is well known, Jenner made public his discovery at once, and never for a moment hesitated as to whether he might not be a richer man by keeping his information to himself.

Jenner was exceedingly fond of music and poetry; some of his verses still live in printed collections. His two best-known poems are perhaps "To a Robin" and "Signs of Rain." The latter was written as an excuse for not accepting the invitation of a friend to make a country excursion, and consists of the popular signs of coming rain ingeniously strung together in rhyme. As four specimen lines we may take the following:

The walls are damp, the ditches smell,
Clos'd is the pink ey'd pimpernel.
Hark! how the chairs and table crack
Old Betty's joints are on the rack.

From a portrait by Vigneron.

Although Jenner met with much opposition in the introduction of vaccination, and had to put up with misrepresentation and abuse in his own time, it has been reserved for certain persons in the present generation to speak of him as a charlatan, a shuffler a fool, and a liar. Surely those who lived with him and knew all the circumstances of the case were better able to judge fairly of the character of the man than those who, living a century later, try to draw a picture of him by distorting facts, and by assigning some bad motive for all his actions. The debates in the House of Commons show clearly in what esteem Jenner was held by men of education in his own time. The bare fact that a man who was a simple country doctor, without any outside influence to assist him, should have risen to the position Jenner held in his profession is a sure sign of the personality and character of the man.

The Medical and Chirurgical Society was founded by the *élite* of the medical profession, and amongst the names of the first Fellows we find that of Edward Jenner. Oxford University must have had a high opinion of his qualifications or the authorities would not have departed from their usual custom and granted him the Honorary Degree of Doctor of Medicine.

JENNER'S WRITINGS.

To the Medico-Convivial Society at Rodborough Jenner contributed several papers; one of these was on Angina Pectoris and another on Ophthalmia. Writing in the *Asclepiad*, vol. vi, p. 268, Sir B. W. Richardson states that "there is no written record bearing on these subjects left behind on which we can found any correct conclusions as to its originality." This is not quite correct, as Dr. Parry, in his "Inquiry into the Symptoms and Causes of the Syncope Anginosa," has given us a communication from Jenner on the subject. Dr. Parry writes as follows: "The substance of the following essay was originally read to a medical society in Gloucestershire. In that society the influence of the heart on the animal economy had often been the subject of discussion. It was generally admitted that many of the cases which are vulgarly called asthma originated, through different media, from diseases of that organ; and it was suggested by Dr. Jenner that the angina pectoris arose from some morbid change in the structure of the heart, which change was probably ossification, or some similar disease of the coronary arteries. To some questions which I have lately put to that excellent pathologist as to the series of observations which produced that opinion, I have received the following answer:

"The first case I ever saw of angina pectoris was that in the year 1772, published by Dr. Heberden, with Mr. Hunter's dissection. There, I can almost positively say, the coronary arteries of the heart were not examined. Another case of a Mr. Carter, at Dursley, fell under my care. In that, after having examined the more important parts of the heart without finding anything by means of which I could account either for his sudden death or the symptoms preceding it, I was making a transverse section of the heart pretty near its base when my knife struck against something so hard and gritty as to notch it. I well remember looking up to the ceiling, which was old and crumbling, conceiving that some plaster had fallen down. But, on a further scrutiny, the real cause appeared; the coronaries were become bony canals. Then I began a little to suspect. Soon afterwards Mr. Paytherus met with a case. Previously to our examination of the body I offered him a wager that we should find the coronary arteries ossified. This, however, proved not to be exactly true; but the coats of the arteries were hard, and a sort of cartilaginous canal was formed within the cavity of each artery, and there attached, so, however, as to be separable as easily as the finger from a tight glove. We then concluded that malorganization of these vessels was the cause of the disease. At this very time my valued friend Mr. John Hunter began to have the symptoms of angina pectoris too strongly marked upon him; and this circumstance prevented any publication of my ideas on the subject, as it must have brought on an unpleasant conference between Mr. Hunter and me. I

mentioned both to Mr. Cline and Mr. Home my notions of the matter at one of Mr. Hunter's Sunday night meetings, but they did not seem to think much of them. When, however, Mr. Hunter died Mr. Home very candidly wrote to me immediately after the dissection to tell me I was right. The appearances in Mr. Bellamy's case gave me the idea that the disease arose from a determination to the vasa vasorum, and that the concretions were deposits from the coagulable lymph, or other fluids, which had oozed out on the internal surface of the artery.'" Dr. Parry then proceeds: "With these observations of Dr. Jenner we were well acquainted in the society. Many of them were, indeed, communicated to us as they arose."

There is no printed collection of Jenner's poetry. Several pieces are printed in Baron's *Life*; there are others in the collection of Jenner papers in the Library of the Royal College of Surgeons of England.

Observations on the Natural History of the Cuckoo, in a letter to John Hunter, Esq., F.R.S., *Phil. Trans.*, vol. lxxviii, p. 219.

A Process for Preparing Pure Emetic Tartar by Recrystallization, by Mr. Jenner, surgeon at Berkeley, in a letter to John Hunter, Esq., read June 4th, 1784, *Trans. of a Soc. for the Improvement of Med. and Chir. Knowledge*, vol. i, 1793, p. 30.

In the Library of the British Museum there is a pamphlet entitled Cursory Observations on Emetic Tartar, wherein is pointed out an improved method of preparing Essence of Antimony by a solution of Emetic Tartar in Wine. Wotton-under-Edge, printed by J. Bence, bookseller and stationer. There is no date, but at the end the pamphlet is signed "E. Jenner, Surgeon, Berkeley, Gloucestershire," in Jenner's own writing. This work seems to have escaped the notice of previous writers on Jenner. The copy in question shows pretty conclusively that it ought to be included in the list of his books. The volume of tracts in which it is bound up at the Museum contains one pamphlet which originally belonged to Dr. Lettsom. It is probable that all the tracts were once his property, and that this one is a presentation copy; this would account for Jenner's signing it.

An Inquiry into the Causes and Effects of the Variolae Vaccinae, a Disease discovered in some of the Western Counties of England, particularly Gloucestershire, and known by the name of the Cow-pox, pp. iv, 75, 4 plates, 4to. London: 1798. Dedicated to C. H. Parry, M.D., at Bath. Preface is dated Berkeley, Gloucestershire, June 21st, 1798.

Again—2nd edition, pp. vii, 182, plates, 4to. London: 1800. Dedicated to "The King." Preface is dated Berkeley, Gloucestershire, December 20th, 1799.

From a painting said to be by Sir Thomas Lawrence in the possession of Mr. T. Malcolm Watson.

Again—3rd edition, pp. vii, 182, 4 plates, 4to. London. 1801. The third edition consists of "The Inquiry," "Further Observations on the Variolae Vaccinae," "A Continuation of Facts and Observations, etc."

The "Inquiry" was also published in America, and translated into Latin and into nearly every European language.

There are two known manuscripts of the "Inquiry" in existence, one in the Library of the Royal College of Surgeons of England, and the other in the collection of Jenner relics belonging to Mr. Mockler. The former MS. is entirely in Jenner's handwriting, the latter in that of his brother-in-law, with notes and corrections made by Jenner himself. The College MS. has been examined by Professor Crookshank, who has come to the conclusion that it is the paper rejected by the Royal Society. This opinion is given mainly on the fact that Jenner had originally written in the MS.: "I shall produce many instances (I could produce a great number more), but the following, I presume, will be fully sufficient to establish the fact to the satisfaction of this learned body." In the MS. these last words are scratched out, and it is made to read "establish the fact very satisfactorily."

Before proving that this paper was rejected by the Royal Society, it will be necessary for the objectors to prove that it was ever received by that learned body. Undoubtedly Jenner originally intended sending the paper to the Royal Society, although Worthington advised him that it would be better to publish it as a pamphlet. What seems to have happened was that Everard Home took it to the Society and showed it informally at a Council meeting. It must not be forgotten that the theory was rather a startling one, and that at that time it was founded on one experiment only. There is not much to be wondered at in the Council referring the paper back to Jenner for further experiments to corroborate his views. Had the paper been formally presented by Home, and had it gone through the regular routine at the Society, there would be evidence of this in the Archives, but no one has ever been able to find any trace of it.

Professor Crookshank was evidently anxious to make the most of the Society which had "rejected" Jenner's paper. In the MS. at the College of Surgeons Jenner calls it "this learned body." This Professor Crookshank, whilst professing to quote verbatim, has altered to "this very learned body."[1] This word "very" is again inserted in vol. ii, p. 9, where the differences between the MS. and the printed pamphlet are pointed out. Professor Crookshank states that this alteration is made "in a different handwriting." This is not so; the

[1] *History of Vaccination*, vol. i, p. 253.

Dear Jenner

I rec'd yours in answer to mine, which I should have answered I own I suspected it would not be; yet as I did intend such a scheme, I was unwilling to give you the offer. I thank you for your Exp[t] on the Hedge Hog; but why do you ask me a question, by the way of solving it. I think your solution is just; but why think why not try the Exp[t]. Repeat the Exp[t] upon a Hedge Hog as soon as you receive this, and they will give you the solution. Try the Hot

cut off a dog at the same place
cut off the Head, and expose
the Heart and cut his throat
the result of the whole

I am Dear Jenner

Ever yours

John Hunter

Aug 2?

Mr Jenner

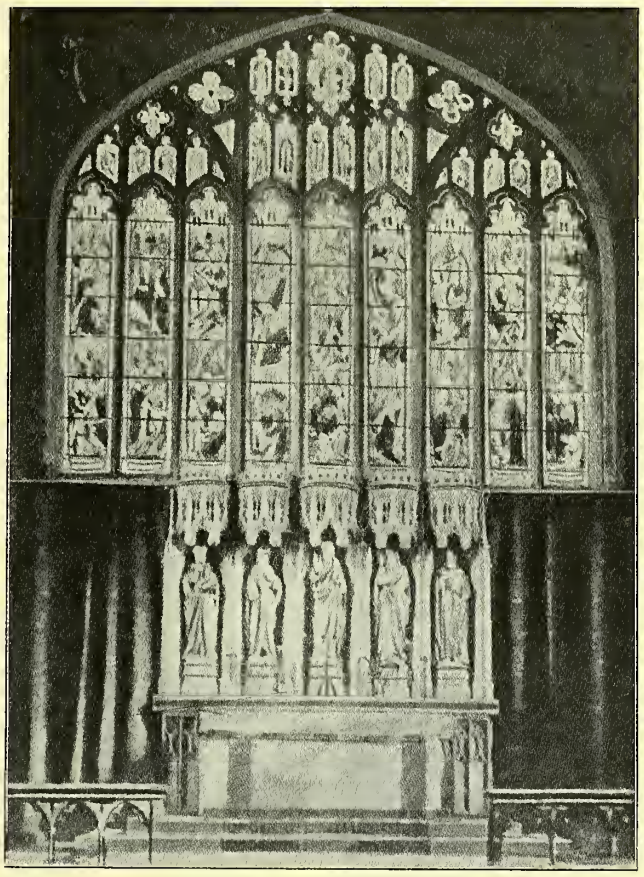
Surgeon at Berkley

Gloucestershire

Berkley

writing is undoubtedly by Jenner himself. It may here be noticed that the quotations from the MS. in Professor Crookshank's book are very incorrect. Jenner writes "malady," Professor Crookshank prints "distemper"; the MS. has "for the same purpose," this appears in print as "in the same manner." Many other instances might be pointed out.

Professor Crookshank writes (vol. i, p. 264): "I was struck by the substitution, in a different handwriting, of the word *investigation* for *discovery*. Some friendly critic had evidently read the manuscript and made this correction, among others. Had Jenner made a discovery, and if so, what was it?.....The correction of his critic was, therefore, fully justified." The page of the manuscript in which this alteration is made is reproduced in facsimile (p. 15), and it will be quite obvious to any one examining it that the word "investigation" is in the same handwriting as the rest of the manuscript, namely, in that of Jenner. The capital *I*, the peculiar *t* and the *g* in the middle of a word, are identical with similar letters in other parts of the manuscript. The "justification" of the critic thus falls to the ground. It may be mentioned that the alteration about "the learned body" is also made in Mr. Mockler's copy, which is somewhat earlier than the College one. This can be seen by comparing the dates mentioned in the two manuscripts. It is not necessary to labour the point as to whether this was the manuscript taken by Home to the Royal Society or not. Even if it could be shown conclusively that the Society did receive and reject the paper, the subsequent history of the work would prove, not that Jenner was wrong, but that the Council of the Society made a mistake in rejecting the paper.



Memorial window in Berkeley Church.

Instructions for the Vaccine Inoculation: a sheet. 1801. Printed by D. N. Shury. Berwick Street, Soho.

On the Origin of the Vaccine Inoculation, pp. 8, 4to. London: 1801. The preface reads: "I am induced to give the following concise History of the Origin of Vaccine Inoculation from my frequently observing that those who only consider the subject cursorily confound the casual cow-pox with the disease when excited by inoculation. —EDWARD JENNER, Bond Street, May 6th, 1801." This pamphlet is very scarce, and was reprinted in 1863 by Mr. J. Brendon Curgenven.

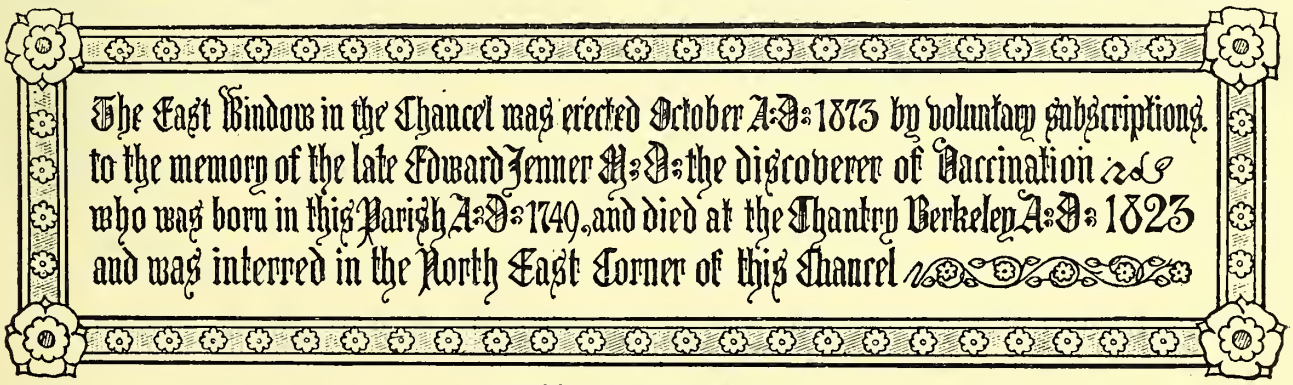
On the Varieties and Modifications of the Vaccine Pustule, occasioned by an Herpetic State of the Skin, pp. 13, 4to. Cheltenham: 1806. The preface is dated Berkeley, March 18th, 1806. Reprinted Gloucester, 1819. This was originally published in *Med. and Phys. Jnl.*, xii, 1804, p. 97, as a letter without any printed title; the headline of p. 98 is "Dr. Jenner, On the Effects of Cutaneous Eruptions;" on pp. 99 to 101, "Dr. Jenner, On Modifications of the Vaccine Vesicle."

Facts for the most part unobserved or not duly noticed respecting Variolous Contagion, pp. 15, 4to. London: 1808. Dated November 18th, 1808.

Observations on the Distemper in Dogs (read March 21st, 1809.) (*Med.-Chir. Trans.*, i, 263).

Two Cases of Small-pox Infection communicated to the Fetus *in Utero* under Peculiar Circumstances, with Additional Remarks (read April 4th, 1809.) (Ibid., i, 269.)

Letter to William Dillwyn, Esq., on the Effects of Vaccination in preserving from the Small-pox. To which are added sundry documents relating to vaccination referred to and



Memorial tablet in Berkeley Church.

Further Observations on the Variolae Vaccinae or Cow-pox, pp. 64, 4to. London; 1799. Dedicated to C. H. Parry, M.D., Bath. Dated Berkeley, Gloucestershire, April 5th, 1799.

A Continuation of Facts and Observations relative to the Variolae Vaccinae or Cow-pox, pp. 42, 4to. London: 1800.

accompanying the letter. Pp. 20, 8vo. Philadelphia: Published by the Philadelphia Vaccine Society. 1818.

A Letter to Charles Henry Parry, M.D., F.R.S., etc., on the Influence of Artificial Eruptions in Certain Diseases incidental to the Human Body, with an Inquiry respecting the

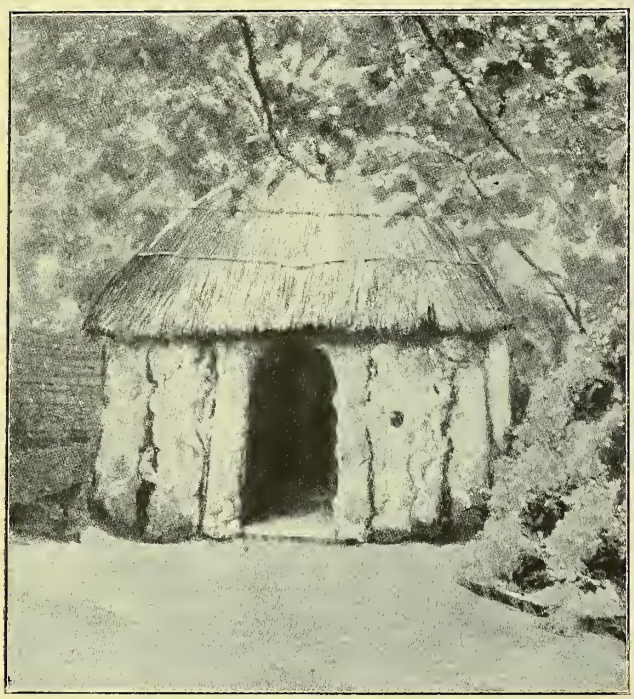
Probable Advantages to be derived from Further Experiments, pp. 67, 4to. London. 1822. This is dated Berkeley, 1821.

Some Observations on the Migration of Birds, by the late Edward Jenner, M.D., F.R.S., with an introductory letter to Sir Humphry Davy, Bart., Pres. R.S., by the Rev. G. C. Jenner. Read November 27th, 1823. *Phil. Trans.*, 1824, p. 11

Portraits of Jenner.

Painting by Sir Thomas Lawrence, now in the possession of the Royal College of Physicians; half length, seated in chair. An engraving of this picture by W. H. Mote forms the frontispiece to the first vol. of Baron's *Life*, and is also the illustration to the Memoir of Jenner in Pettigrew (see p. 8).

Painting said to be by Sir Thomas Lawrence, in the possession of Mr. T. Malcolm Watson. On the back of the picture is the following written statement: "This original portrait of Dr. Jenner executed by Sir Thomas Lawrence was presented by him to his former pupil and intimate friend, Mr. Henry Wyatt, at whose death it became the property of his brother Mr. Thomas Wyatt. The widow of the latter presented it to her sister Mrs. Edward Wünsch, of Glasgow, from whom I received it as a New Year's gift on 1st January, 1862.—Thos. Watson." The present owner is the son of Dr. Thomas Watson, who wrote the above note (see p. 10).



"Temple of Vaccina," in Jenner's Garden.

Painting by James Northcote, painted for the Medical Society of Plymouth and Plymouth Dock; seated, fur collar, etc., right hand on paper bearing legend "Pustules of the Cow Pox in its successive stages." Engraving of the above by W. Say.

Painting by James Northcote, exhibited in the Royal Academy 1803; now in the National Portrait Gallery. (See p. 4).

Portrait in Medley's group of the Founders of the Medical Society of London. Jenner was not in the original picture, but was subsequently introduced. The engraving by Branwhite was partly finished before this was done, and a piece of copper had to be let in the plate, so that Jenner's head and shoulders might be engraved on a spot previously occupied by background details.

Painting by William Hobday represents Jenner seated; cloak with fur collar round him; left arm rests on volume lettered "John Hunter"; paper relating to vaccination lying on table. Engraving of the above "begun by the late William Sharp," finished by William Skelton. Whilst sitting for this portrait Jenner wrote the following verse:

> Ere you finish your job, Mr. Hobday, you'd better
> On each of his legs clap a bit of a letter,
> Or the doctor will presently show you some fun—
> Yes, start from the canvas and certainly run.

J. R. Smith. Engraving in mezzotint. Jenner is represented leaning against a tree; milkmaid and cows in the distance. Engraving of the above by R. Page. 1823. (See p. 7.)

J. Hazlitt, jun. C. Turner, sculptor. London: Published October 20th, 1808, by J. Hazlitt, No. 109, Great Russell Street, Bloomsbury.

Oil painting. Artist unknown. In Royal College of Surgeons of England.

In the collection of portraits at the Royal Medical and Chirurgical Society there is a small photograph said to be "from an original portrait in the possession of Mr. William Smith of Chesterfield."

Portrait by Vigneron, lithographed by C. de Lasteyrie, 1824. This was reproduced in the *Asclepiad*, vol. vi, p. 250. Also lithographed by Engelmann. (See p. 9.)

Portrait of Jenner in a cocked hat. *Hicks sc.* Published by Henry Fisher. Caxton. London: March 1st, 1823.

Miniature by J. Robinson. Jenner with pen, ink, and paper in front of him; cow lying down in back. This is in Mr. Mockler's collection. There is an engraving of this by R. M. Meadows.

Head on large scale, drawn and etched by H. E. Shrapnell.

Oil painting. Artist unknown. In Mr. Mockler's collection.

Medallion. J. B. Drayton, ad viv. del. Anker Smith, A.R.A., sculp. Published February 1st, 1823, by J. B. Drayton, Cheltenham, Gloucestershire.

Silhouette from the title page of Lettsom's "Hints Designed to Promote Beneficence, Temperance, and Medical Science," vol. iii, 1801.

Statues.

Bronze statue by Calder Marshall, R.A., now in Kensington Gardens. This statue was originally in Trafalgar Square, but was removed to Kensington Gardens in 1862. The cost was defrayed by public subscription raised by a committee, of which Dr. Conolly was Chairman and Mr. G. V. Irving Secretary. The statue was unveiled by the Prince Consort in May, 1858. An interesting feature of this ceremony was that amongst those who spoke was the Marquis of Lansdowne, who, as Sir W. Petty, had proposed the resolution in the House of Commons for the grant to Jenner. There is an engraving of the statue by J. Brown. (See p. 5.)

Statue by Sievier at the west end of the nave of Gloucester Cathedral, erected by subscription.

Statue at Brünn, in Moravia.

Bust by H. Corbould. A lithograph of this bust by R. J. Lane forms the frontispiece to vol. ii of Baron's "Life of Jenner."

Bust by S. Manning. Lithograph by M. Gauci, published by N. Chater and Co., 33, Fleet Street, and Washbourn and Son, Gloucester, August 10th, 1823.

Marble statue by Monteverde. Exhibited at the Paris Exhibition of 1878. Now at Boulogne. Jenner is represented vaccinating a child. (See p. 1.)

There is also a memorial window in Berkeley Church with the following inscription: "The east window in the chancel was erected October, A.D. 1873, by voluntary subscriptions to the memory of the late Edward Jenner, M.D., the discoverer of vaccination, who was born in this parish A.D. 1749, and died at the Chantry, Berkeley, A.D. 1823, and was interred in the north-east corner of the chancel."

Medals.

The description of the medals in the following list is taken from an interesting paper by Dr. Storer in the *American Journal of Numismatics*, 1894 and 1895.

Obverse: Apollo presents a sailor who has been preserved by vaccination to Britannia, who holds a civic crown bearing Jenner. Legend, ALBA NAUTIS STELLA REFULSIT, 1801. *Reverse*: An anchor. Above, GEORGIO TERTIO REGE. Below, SPENCER DUCE (Viscount Althorp, First Lord of the Admiralty, and subsequently Earl Spencer). Presented to Jenner by the surgeons of the British Navy. Its locality is now unknown.

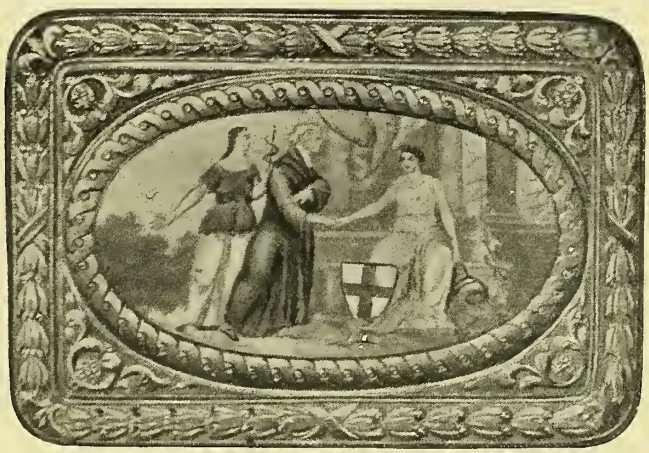
Obverse: DON. SOC. MED. LONDON. ANNO SALUT. 1773. INSTITUT. E. JENNER, M.D. SOCIO SUO EXIMIO OB VACCINATIONEM EXPLORATAM. *Reverse:* Apparently blank (the medal

XX 42

Investigation

Should it be ask'd whether this discovery is a matter of mere curiosity or whether it tends to any beneficial purpose? I should answer, that, notwithstanding the happy effects of inoculation, with all the improvements, which the practice has received since its introduction into this country, we sometimes observe that it proves fatal; & from this circumstance we feel, at all times, somewhat alarm'd for its consequences. But as fatal effects have been never known to arise from the Cowpox, even when impress'd in the most unfavorable manner, that is, when it has accidentally produc'd extensive inflammation, and suppurations on the hands; and as it clearly appears

cannot be traced). Gold. Presented by the Medical Society of London, March 4th, 1804. Baron calls this medal "Gold Medal of the London Medical Society." The minutes of the Society show that it was a Fothergillian medal. On October 10th, 1803, a resolution was moved by Dr. Lettsom and seconded by Sir J. Hayes: "That it be recommended to a future meeting of the Council to consider the propriety of voting the Fothergillian medal to Dr. Jenner as a testimony of respect to the discoverer of vaccine inoculation." On November 7th, 1803, it was resolved, on the motion of Dr. Lettsom, seconded by Dr. Bradley, to present to Jenner "a gold medal, value 10 guineas, struck from the Fothergillian die, and accompanied with a suitable inscription." November 21st, 1803: "Dr. Sims, Dr. Pinckard, Dr. Yellowly, and Mr. Aikin were nominated a committee to consider of an address to Dr. Jenner, and of an inscription for the medal voted by the Society to be laid before the Society at the ensuing meeting." November 28th: The report of the Committee was brought up and various inscriptions were proposed, all of which were referred to a future meeting. February 13th, 1804: It was resolved that the motto to the gold medal to be delivered to Dr. Jenner be the following: "E. Jenner, socio suo eximio ob vaccinationem exploratam." Dr. Lettsom was requested to present the medal at the ensuing meeting, and "to add any remarks that may appear to him worthy of the attention of the Society." Jenner was unable to attend the meeting on March 8th, 1804, and receive the medal personally. Dr. Sims was therefore appointed to receive it on Jenner's behalf. The address delivered by Dr. Lettsom is printed in the *European Magazine*, vol. xlvi, p. 163.



Obverse: An allegorical group. *Reverse:* EDUARD JENNER, DOCTOR IN DE GENESKUNDE, GEBOREN DEN 17 MEY, 1749, TE BERKLEY IN HET GRAAFSCHAP GLOCESTER IN ENGELAND EN ALDAAR OVERLEDEN, DEN 26 JANUARII, 1823, UITVINDER DER KOEPOKINENTING IN HET JAAR, 1775, DOCH EERST IN 1798 DOOR HEM BEKEND GEMAAKT. Copper. By A. Bemme, at expense of H. Westhoff, jun.

Obverse: Between a rose bush and a cornucopia an infant with rose in hand points to its arm. At right of bush: L(oos). Inscription: EDUARD JENNER'S WOHLTHÆTIGE ENTDECKUNG. Exergue: vom 14 MAI 1796. *Reverse:* ZUM ANDENKEN AN ERHALTENEN UND MITGETHEILTEN SCHUTZ (a scroll) GEREICHT VOM DOCTOR BREMER IN BERLIN. 1803. Silver.

As preceding, save upon reverse there follows after SCHUTZ ——. ——, and after Berlin: ——

Obverse: Bust, to left. Beneath shoulder: F. LOOS. Inscription: EDUARD JENNER ENTDECKER DER SCHUTZ IMPFUNG. D. 14 MAI 1796. *Reverse:* An angel from clouds garlanding a cow around which seven children are dancing. Legend: EHRE SEY GOTT IN DER HÖHE. Exergue: UND FREUDE AUF ERDEN. Silver, bronze.

Obverse: As preceding, save that engraver's name is in exergue. *Reverse:* Hygeia, with serpent upon her right arm, protects by a shield bearing a cow an infant against a flying demon. Legend: TRIUMPH! GETILGET IST DES SCHEUSALS LANGE WUTH. Silver, bronze, Berlin iron.

Obverse: A child between a rose tree and a rising sun exhibits its arm; at its feet a serpent. Legend: DANK DER GUTIGEN VORSEHUNG. Exergue: Kruger. *Reverse:* Within a pearled octagon: WOHL THATIGE ENTDECKUNG DER SCHUTZPOCKEN DURCH ED. JENNER. Silver.

Obverse: Bust, facing, within palm branches. Inscription: EDWARD JENNER. To left: HAMEL ET LECOMPTE. Beneath: 1749 (the date of Jenner's birth). *Reverse:* Between laurel branches: MEDAILLE DE 1RE CLASSE. Inscription: COMITÉ CENTRAL DE VACCINE DU DEPARTEMENT DU NORD. Silver.

Obverse: Like preceding, but bust somewhat towards the left and on pedestal, on the base of which is the date. *Reverse:* A laurel wreath, beneath which: MEDAILLE DE 2E CLASSE. Field vacant for name of recipient.

Obverse: Bust upon an oval shield between two females holding over it a crown. Beneath, an elongated shield upon which is a cow, to right. *Reverse:* Blank. Plaster-of-paris.

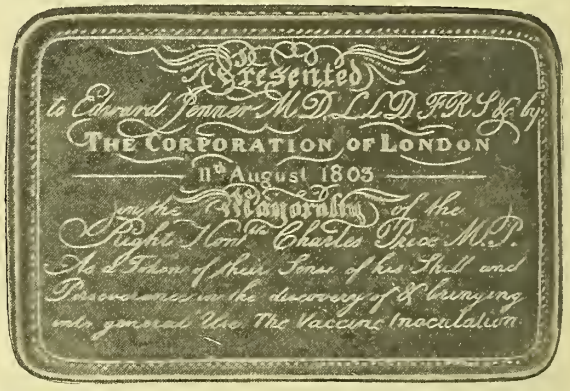
Obverse: Bust, clothed, to left. Upon truncation: (T. R.) Poole, 1809. No inscription. *Reverse:* Blank. Of pinx wax upon colourless transparent glass. (In Library of the Royal Medical and Chirurgical Society of London.)

LIST OF DIPLOMAS, HONOURS, ETC.

Chronological list of diplomas, honours, addresses, presented to Jenner, compiled from the Appendix to Baron's "Life."

Several of these diplomas are in the collection of Jenner relics formed by Mr. Mockler.

1801. February 20th. Plymouth Dock. Address from Dr. Trotter and forty-four medical officers of the navy, subscribers to the Jennerian Medal.



May 29th. Address of respect and application for imbued threads, from the "Physician delegated" of the Department de l'Agogna (Cisalpine Republic).

16 Thermidor. Address from the Bureau of the National Institute of France, and thanks for the dissertation communicated to them.

September 14th. Diploma of Fellow of the Royal Society of Sciences at Göttingen.

1802. February. Certificate of the success of Vaccine Inoculation, and complimentary address thereupon, from the staff of the Manchester Infirmary.

February 20th. Diploma of Fellow of the Physical Society of Guy's Hospital.

February 25th. Testimonial and address from the Presidents and members of the above Society.

March 7th. Diploma of Fellow of the Royal Medical Society of Edinburgh.

24 Ventôse. Diploma of Foreign Associate of the Medical Society of Paris.

30 Germinal. Official address from the Medical Society of Indre et Loire.

May 25th. Diploma of Fellow of the American Society of Arts and Sciences.

July 29th. Official letter of respect and congratulation upon the general success of vaccination in France, from the Central Committee of Vaccination.

August 10th. Letter from the Dowager Empress of Russia, signed "Marie," and accompanied by a ring set in diamonds.

2 Messidor. Diploma of Corresponding Associate of the Medical Society of Tours.

27 Brumaire. Appointment of Associate from a Society at Avignon.

1803. March 16th. Diploma of Member of the Society of Medicine at Avignon.

August 11th. Freedom of the City of London, presented in a gold box of the value of 100 guineas. The gold box mentioned was sold by auction on October 25th, 1893, by Messrs. Debenham, Storr and Son. It was described in the catalogue as "A magnificent 18-carat gold presentation snuff-box, beautifully enamelled, with the arms of the City of London and other subjects, and bearing an interesting inscription, date 1803, 11 ozs. 11 dwt." The inscription reads as follows: "Presented to Edward Jenner, M.D., LL.D., F.R.S., etc., by the Corporation of London, 11th August, 1803, in the Mayorality of the Right Hon. Charles Price, M.P., as a token of their sense of his skill and perseverance in the discovery of and bringing into general use the vaccine inoculation." In describing it as a "snuffbox" the auctioneers fell into error. At the sale the casket fetched what it originally cost, 100 guineas. It is now the property of the Society of Apothecaries. The document originally contained in the box is in Mr. Mockler's collection of relics.

August 15th. Diploma of Fellow of the Royal Medical and Economical Society of Madrid.

August 31st. Diploma of LL.D. from the Senate of Harvard University.

September 14th. Diploma of Honorary Member of the Royal Humane Society of London.

28 Vendemiaire. Diploma of Foreign Associate of the School of Medicine at Paris.

21. Frimaire. Diploma from the Society of Medicine, Departement du Gand.

1804. March. Freedom of the City of Dublin.

April 7th. Diploma of Member of the American Philosophical Society.

October 31st. Freedom of the City of Edinburgh.

December. Diploma of Fellow of the Imperial University of Wilna.

1806. March 31st. Diploma of Foreign Associate of the Royal College of Physicians at Stockholm.

May 20. Diploma of Honorary Fellow of the Royal College of Physicians at Edinburgh.

1807. March 5th. Diploma of Honorary Associate of the Royal Economical Society of Valencia.

April 1st. Freedom of the Borough of Liverpool.

April 23rd. Diploma of Foreign Associate of the Royal Academy of Sciences at Stockholm.

November 8th. Address of the Five Nations of Indians assembled in Fort George in Upper Canada. With the address was sent a belt and string of wampum.

1808. March 28th. Diploma of Fellow of the Royal Academy of Sciences at Munich.

May 25th. Diploma of the New Hampshire Medical Society.

June 20th. Diploma of Corresponding Member of the National Institute of France in the class of Physical and Mathematical Sciences.

September 1st. Freedom of the City of Glasgow.

1809. April 27th. Freedom of the Burgh of Kirkcaldy.

1810. April 27th. Diploma of Honorary Member of the Literary and Philosophical Society of Manchester.

1811. May 13th and 19th. Diploma of Foreign Associate of the Imperial Institute of France in the class of Physical and Mathematical Sciences.

1813. December 3rd. Diploma of Doctor of Medicine of the University of Oxford. This was a great honour to Jenner, as the granting of an Honorary M.D. by the University is a very rare occurrence.

1814. July 1st. Diploma of the Royal Society of Medicine at Bordeaux.

October 20th. Address of the Inhabitants of Brünn, in Moravia.

1815. January 20th. Address of Honorary Associate of the Physico-Medical Society of Erlangen.

1821. March 16th. Appointment of Jenner as Physician Extraordinary to H.M. King George IV.

1822. August 30th. Diploma of Foreign Correspondent to the Medico-Chirurgical Society of Berlin.

A

Series of Communications

ON

SMALL-POX AND VACCINATION.

THE EPIDEMIOLOGY OF SMALL-POX IN THE NINETEENTH CENTURY.

BY ARTHUR NEWSHOLME, M.D., F.R.C.P.,
Medical Officer of Health of Brighton.

THE study of the epidemiology of small-pox is probably more difficult than that of any other infective disease. The infective diseases which occur at intervals, in the prevalence of which there is evidence of flood-tides and ebb-tides, may be grouped under three heads. There are, first, diseases which, like typhus, become epidemic only under conditions of overcrowding, or like relapsing fever only when overcrowding is combined with starvation, or like enteric fever only when there is excretal contamination of food or water. There are, secondly, diseases which, like measles and whooping-cough, recur with mechanical regularity every second or third year with the accumulation of susceptible children. There are, thirdly, diseases, like scarlet fever, diphtheria, and rheumatic fever, which although they are, like many of the preceding diseases, in a minor degree constantly endemic, only become widely epidemic under the influence of certain favouring climatic conditions. Gresswell and Longstaff have shown an inverse relationship between rainfall and the death-rate from scarlet fever; and I have shown that epidemics of rheumatic fever, and still more of diphtheria, occur in the course of a succession of dry years immediately following each other. It is not pretended that the preceding groups are mutually exclusive, but they form a convenient classification in connexion with my present subject. We have, fourthly, small-pox, which, like measles and whooping-cough, appears to become epidemic on a small scale at intervals of a few years—in this case usually three or four instead of two—and at longer intervals, on two or three successive occasions of thirty years, has become widely pandemic. In this occasional occurrence of widespread pandemics, there is a close analogy with the major epidemics of measles described by Whitelegge, and with the pandemics of diphtheria which I have elsewhere described.

We have, then, to study in relation to small-pox (1) its regular periodical epidemicity and (2) its less regular and less frequent major epidemics and pandemics.

I began by stating that the study of the epidemiology of small-pox is probably more difficult than that of any other disease. This is because a successful means of preventing the occurrence of small-pox, and a means even more successful of preventing death from it in those attacked, has been discovered in vaccination, and largely utilized. In this respect small-pox is unique among the diseases of humanity. From the standpoint of one desiring to study the epidemiology of small-pox, and from that standpoint alone, vaccination is a serious drawback, inasmuch as it has obscured the epidemiology of the disease, smoothed out the epidemic peaks of the curve of annual mortality, and caused its valleys to sink into insignificance or disappear, becoming identical with the base-line of the diagram of annual incidence.

The ideal diseases for the epidemiologist are measles and whooping-cough, in which, for reasons which need not be considered here, it has been hitherto practicable to do little or nothing interfering with the natural cycles of disease. They spread by personal infection, and the task of preventing their spread by early isolation has hitherto been unmanageable, and will probably remain so for many years. In small-pox, on the other hand, the task of isolation has been rendered practicable by protective vaccination of all who have come into contact with the small-pox patient. In antivaccination towns like Leicester, as well as in towns in which agitation against vaccination has been less successful, there is the same ring of insusceptible, because vaccinated, persons around each small-pox

patient. I am not, however, concerned in this paper to determine the relative value of vaccination and isolation in the prevention of small-pox.* It suffices for my purpose that conjointly they have succeeded in wiping out to a very large extent the epidemic peaks of small-pox in this country. This is graphically illustrated in the following scheme, the number of deaths that would have occurred apart from the measures adopted being represented by the higher and the actual number of deaths by the lower dotted curve. Hence when recent are considered in relation to earlier epidemics of small-pox, the quantitative comparison is to a considerable extent vitiated by the preventive measures that have been adopted. Inasmuch, however, as in the present article we shall be concerned more with the intervals between epidemic peaks than with the actual height of these peaks, a study of the epidemiology of small-pox is still practicable.

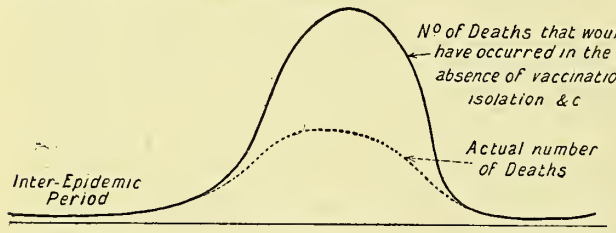


Fig. 1.

It is to be noted, however, that preventive measures may in some instances have entirely altered the epidemicity of the disease. If the first cases of small-pox introduced into a given city are recognized and isolated and all the "contacts" vaccinated, or even if, apart from such early recognition, every inhabitant is protected by efficient vaccination and revaccination, then the occurrence of an epidemic is as impossible as the growth of grass on a stone pavement. The nearest approach to this condition of things is seen in the diagrams of the death-rate from small-pox in Hamburg, Stockholm, and in Christiania (Figs. 5, 10, and 15). Allowance must therefore be made in a study of the epidemicity of small-pox for the operation of these factors. This can be done, and is done in the following description of the epidemicity of small-pox in the nineteenth century, by comparison of towns in which vaccination and revaccination and hospital isolation are enforced with those in which no systematic efforts in these directions have been made.

Another point needs consideration in a study of epidemicity. Should the statistics for an entire country or for a limited community, such as a great town, be studied? If the statistics of an entire country are taken, I have shown that in diphtheria and rheumatic fever the epidemic curve is less acuminated and more protracted than for single towns. So, likewise, for small-pox. Hence, wherever practicable, the statistics for large towns are preferred in the following study. The statistics of small towns are not so trustworthy as those of large towns, because in the former the chances of importation are less numerous; and, apart from importation of variolous infection, epidemicity cannot manifest itself except in those few centres in which a few cases of small-pox are always present. Even in London, each epidemic has been more or less clearly traceable to infection imported from Paris or other communities in which small-pox was prevailing at the time.

SMALL-POX IN LONDON.

Fig. 2 shows the annual death-rate from small-pox in London from 1780 up to the end of the first quarter of the year 1902. It is taken from a table presented by Dr. A. R. Wallace to the Royal Commission on Vaccination[1] so far as the years 1780 to 1837 are concerned. As the registration of causes of death only came into operation in the latter year, the statistics for preceding years, derived from the London Bills of Mortality, are probably deficient, and the death-rates from small-pox therefore considerably understated.

The first point striking one in this diagram is the rapid decline in the death-rate from small-pox from 1800 onwards. In 1801 vaccination was introduced, and rapidly found favour among the population. Coincidently with the introduction of vaccination the practice of inoculation declined, though it was still common until it became illegal in 1840. By anti-vaccinists the stopping of inoculation is given a higher place as a cause of the decline from 1800 to 1840, shown in Fig. 2, than vaccination, if the latter is to be admitted to any place whatever. This point can only be properly discussed by reference to the statistics of small-pox before inoculation was introduced into England in 1721.

EXTENT OF INOCULATION AND VACCINATION.

Inoculation after its introduction is stated by Dr. Edwardes in his admirable *Concise History of Small-pox and Vaccination in Europe* (1902) to have made but slow progress in popular favour. By the year 1768, in the London "stations" for the purpose, only 6,581 persons had been inoculated. "Towards the end of the century it came into more general use amongst the richer classes, to which it was chiefly confined. During

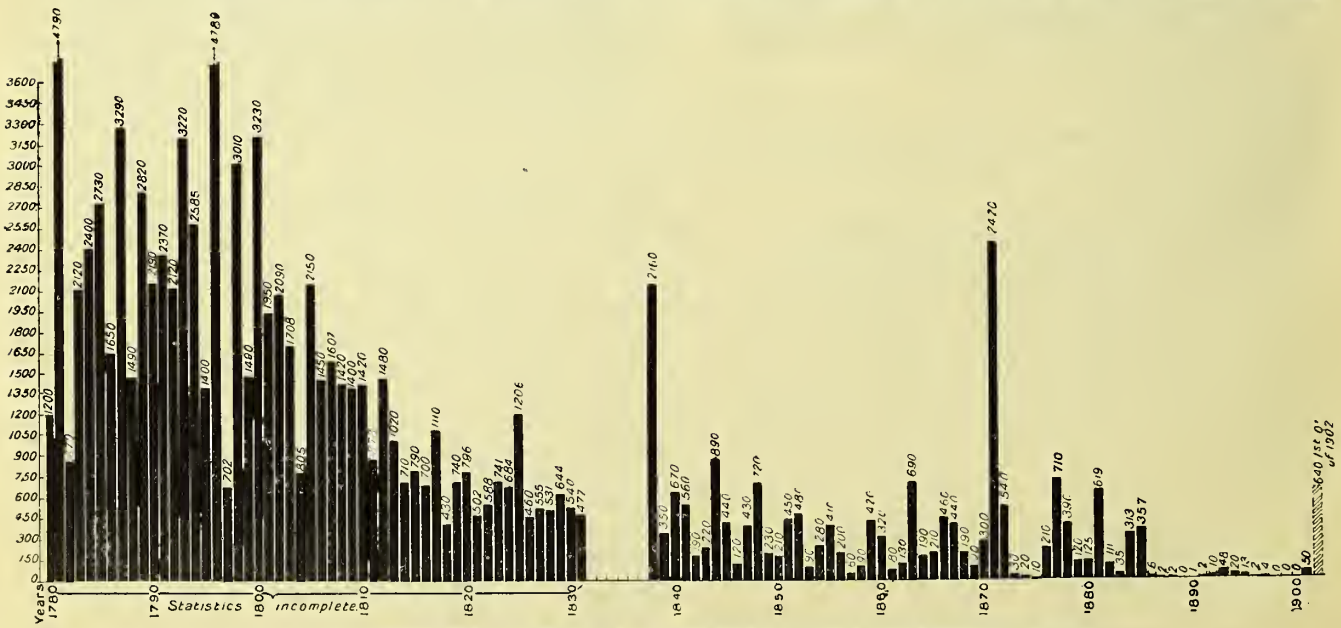


Fig. 2.—Annual death-rate per million of population in London from small-pox, 1780–1902.

*The greater importance of vaccination is shown by the fact that in most of the communities, the experience of which is graphically shown in the following diagrams, the lion's share of the decline in the death-rate from small-pox occurred before isolation was attempted on any large scale.

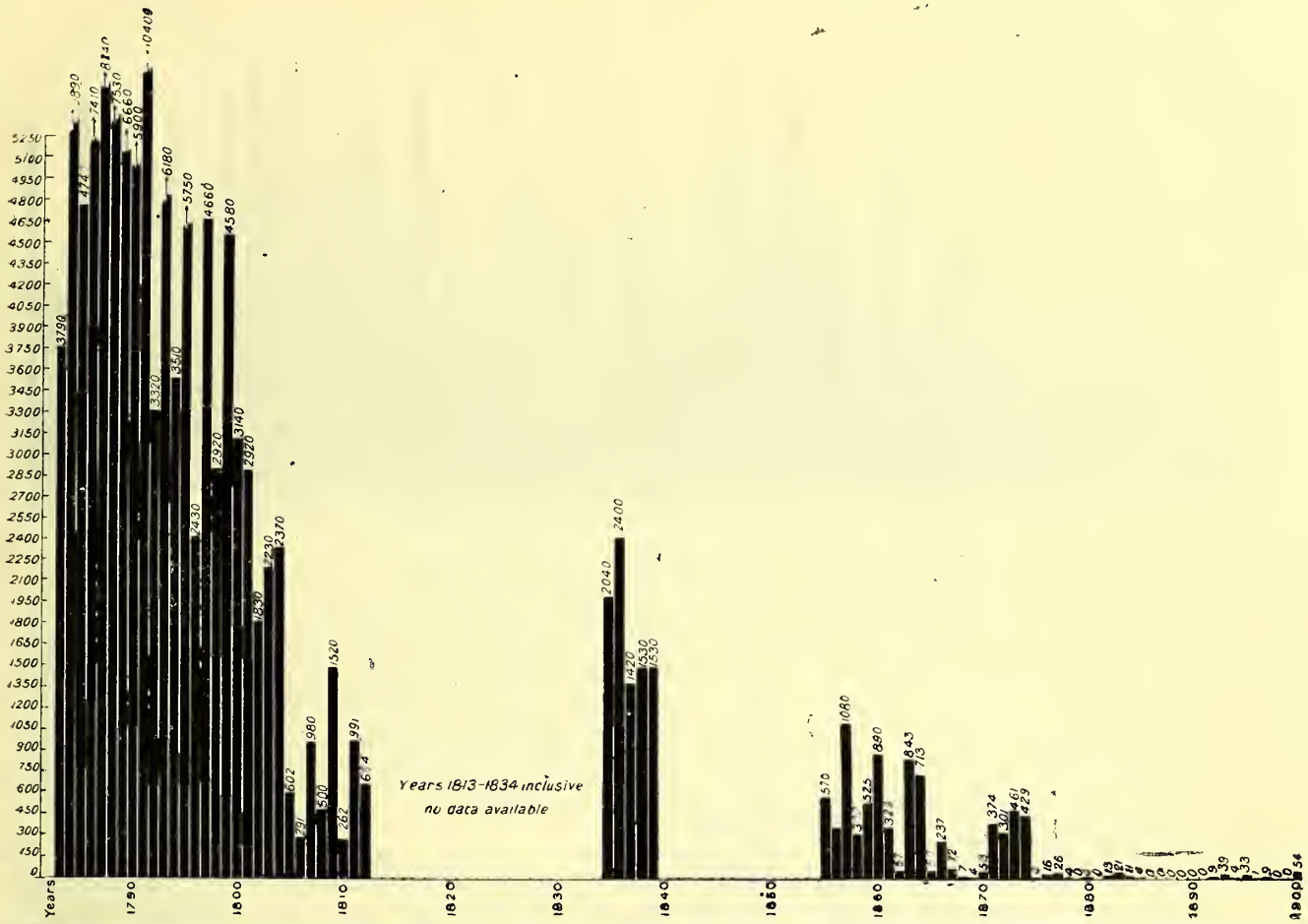


Fig. 4.—Annual death-rate in Glasgow from small-pox per million inhabitants 1787-1812, 1835-39, and 1855-1900. (No statistics are available for 1840-54.

1764-66 a quack, Daniel Sutton, and his assistants inoculated 20,000 persons." The Report of the Royal Commission on Vaccination (p. 17) states, "It seems probable that inoculation did not tend to increase the prevalence of small-pox." They add that during the first quarter of the eighteenth century there was, broadly speaking, no inoculation, during the second quarter very little, while it was widely practised in the second half of the century. In 1796 Jenner performed his first vaccination. In March, 1801, he was able to state that already at least 100,000 persons had been vaccinated in England alone, and the practice rapidly spread.

What Evidence is there that Inoculation increased the Prevalence of Small-Pox?

In the diagram (Fig. 3) the annual deaths from small-pox from 1646 to 1820, as set out in the London Bills of Mortality,[2] are plotted. It will be noted that total deaths and not death-rates are given, and that no allowance is made for increase in population. This diagram overlaps from 1780 to 1820 with Fig. 2 dealing with death-rates from small-pox. This has been done intentionally to allow it to be seen that the scales adopted in Figs. 2 and 3 are as nearly the same as could be conveniently arranged.

If the records are trustworthy, in the sense of being equally complete throughout (a doubtful point), there was more small-pox in the eighteenth than in the second half of the seventeenth century. It is not, however, clear that there was a great deal more small-pox in the second half of the eighteenth century, in which inoculation was prevalent, than in the first half of that century, when it had been scarcely introduced, if allowance be made for the increase of population. This increase can only be surmised, as the first census was in 1801. According to the Bills of Mortality the total number of deaths from small-pox in London was:

—	Years.	Deaths.
50 years	1651-1700	35,291
50 years	1701-1750	93,753
50 years	1751-1800	101,952

In the 40 years (1701-1740) before inoculation was practised to any considerable extent in England, the number of deaths from small-pox was 75,220. In other words, deaths from small-pox increased at a higher ratio in the years preceding than in the years following the introduction of inoculation. It may be said, however, that inoculation increased the frequency of epidemics of small-pox, even though it did not increase their fatality. Fig. 3 enables an answer to be given to this question.

Intervals between Epidemics.

An examination of Fig. 3 shows alternating years of minimum and maximum mortality from small-pox. The intervals between epidemics are taken as the number of years intervening between the apices of the diagram. In a few instances very trifling maxima are ignored. Now, if the diagram be studied from this standpoint the following results are obtained:

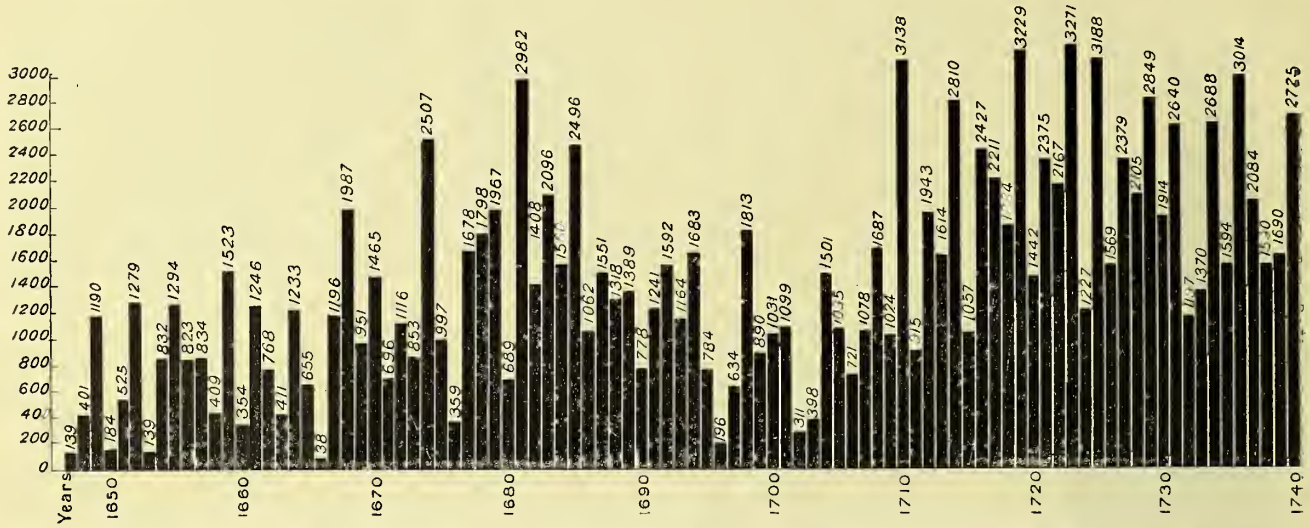


Fig. 3.—Annual deaths in London caused by small-pox, 1647 to 1820, as returned in the London Bills of Mortality. (Note.—Dr. McVail states that from 1678 to 1701 small-pox was not distinguished from measles.)

No. of Years Intervening between Epidemics (as defined above).

Fig. 3	Second half of 17th century	2, 3, 1, 2, 3, 3, 4, 1, 1, 1, 1, 4, 1, 3, 2
	First half of 18th century	2, 3, 1, 3, 1, 2, 3, 1, 3, 1, 2, 1, 3, 1, 2, 2
	Second half of 18th century	2, 1, 2, 1, 3, 4, 3, 2, 1, 1, 3, 1, 1, 3, 2, 1, 1
Fig. 2	Years 1800 to 1831 ...	1, 2, 1, 4 (or 2), 4, 2, 4, 3
	Years 1838 to 1850 ...	2, 3, 3, 3
	Years 1851 to 1900 ...	2, 3, 3, 2, 4, 5, 3, 3, 8

There is no evidence of increased frequency of epidemics in the second half of the eighteenth century. Both before and after the introduction of inoculation small-pox was endemic to an enormous extent, epidemic exacerbations occurring every second or third year. Even in the present century (Fig. 2) the same tendency for small-pox to recur at fairly regular intervals is seen. The epidemic waves are smaller in dimensions, but their presence is obvious; and the regularity of their occurrence reminds one of the almost mechanically regular recurrence of the epidemic peaks of measles. Those wishing to study the measles and small-pox curves comparatively should consult the figure in Dr. McVail's article[3] in Stevenson's and Murphy's *Hygiene*.

Factors of Epidemicity.

According to Hirsch[4] there are two factors only that determine the recurrence of an epidemic of small-pox; on the one hand the necessary number of persons susceptible of the morbid poison, and, on the other hand, the introduction of the virus itself. Figs. 2 and 3 at first sight appear to support this view. The question as to whether any other factors are concerned—in my opinion such factors exist—will be more conveniently postponed until the epidemiology of other parts of Europe has been considered. Meanwhile it suffices to have shown that small-pox still recurs at intervals of a few years, that these intervals are a little longer than formerly, and that the conditions for the production of the frequent great epidemics of the past apparently continue, apart from the operation of a great inhibitory force. This force is not improved sanitation. No scrap of evidence is forthcoming which shows any connexion between small-pox and bad drainage or other sanitary defects except overcrowding. In this respect small-pox is like measles and whooping-cough. It is most easily spread when the most frequent opportunities exist for personal intercourse. Now the most noteworthy feature of the last half of the nineteenth century is the increased urbanization of the population, and the immense extension of travelling conveniences. And yet, notwithstanding the increase of these adverse influences the small-pox death-rate has rapidly declined. Hospital isolation of cases has undoubtedly diminished the spread of the disease; but it did not come into general operation until the greatest part of the decline in small-pox mortality had occurred; and hospital isolation has only been rendered completely practicable by securing doctors, nurses, and other attendants who are protected against the disease by revaccination. Over and beyond the effect of isolation is the fact that the pabulum for the disease is removed in a well-vaccinated community.

Small-Pox in Glasgow.

It will only be necessary to take a second example of the epidemicity of small-pox in Great Britain, and Glasgow has been selected, as I have been able to obtain returns for this city for a longer series of years than for any other town, and its population is sufficiently large and the opportunitities of importation of infection are sufficiently great, to obviate accidental causes for the non-recurrence of epidemics. The deaths from small-pox for 1783-1813 and for 1835-1839 are obtained from Creighton's *History of Epidemics*, vol. ii, p. 655. The death-rates which I have calculated from his figures are based on estimated populations, and are only approximately accurate. The death-rates for 1855-94 are obtained from Dr. J. B. Russell's most valuable brochure on the *Evolution of the Function of Public Health Administration* (p. 135). It is convenient to interpolate here Dr. Creighton's remark[5]: "In Glasgow, where the old inoculation was either little practised or of little use, the Jennerian mode was received with favour, and was offered to the children of the working classes gratuitously at the Hall of the Faculty of Physicians and Surgeons."

Fig. 4 enables some conception to be obtained of the enormous endemic prevalence of small-pox in Glasgow from 1787 to 1800. Soon after 1800 an even more striking decline, interrupted by epidemic recurrences, occurred. The years 1835-9 almost certainly corresponded with one of these recurrences. In the midst of the enormous endemicity during the eighteenth century there is visible a biennial epidemic. Between 1798 and 1804 for the first time four years intervene between two epidemic apices. Four years again elapse in the next interval.

From 1857 onwards to 1874, the corresponding intervals are in succession 2, 2, 2, and 4 years. After 1874 the epidemic peaks are so small as to be recognizable with difficulty, but they appear to have occurred at intervals of five and eight years.

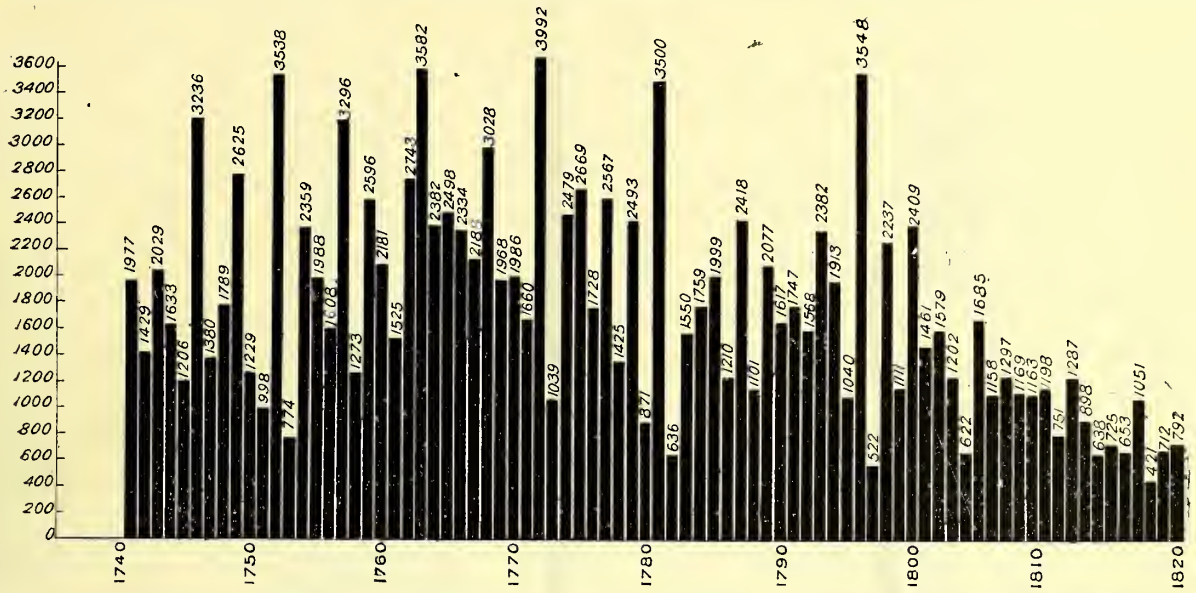


Fig. 3 (*continued*).—Annual deaths in London caused by small-pox, 1646 to 1820, as returned in the London Bills of Mortality.

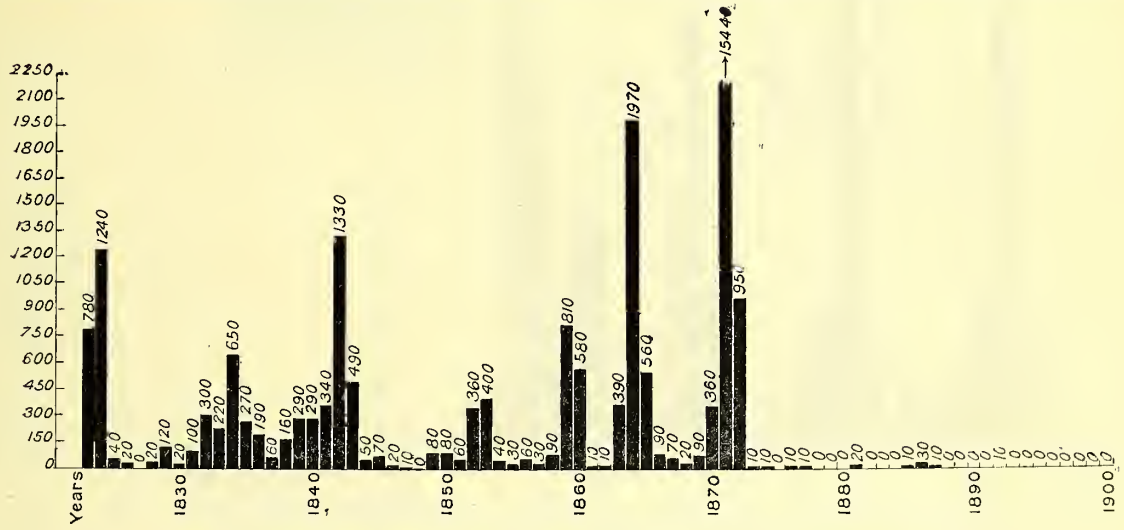


Fig. 5.—Annual death-rate in Hamburg from small-pox per million inhabitants 1821-1900.

HAMBURG.

A recent valuable review of the health of Hamburg during ninety years by Dr. Reincke (*Die Gesundheitsverhältnisse Hamburgs im neunzehnten Jahrhundert*, 1901), gives the necessary data for Fig. 5.

From this diagram it will be seen that the number of years intervening between successive epidemic peaks was 8 or 9, 7, 10, 5, 4, and 6. After 1872 epidemic peaks are invisible, but in 1881 and ‡1885 feeble attempts at an epidemic rise were made.

PRAGUE.

With the experience of Hamburg that of Prague may be contrasted.[6] Unfortunately it only relates to a comparatively recent period. For that period, however, the contrast in amount of small-pox is striking. Epidemic peaks occur with 2, 3, 3, and 3 years intervening in succession.

FLORENCE.

The statistics for Florence[7] 1866-90 (Fig. 7) show epidemic peaks with 3, 5, 4, and 4 intervening years in succession.

PARIS.

For a statement of annual deaths in Paris from 1817-56 and 1865-1901, I am indebted to the personal kindness of Dr. Jacques Bertillon, the head of the Statistical Bureau of the City of Paris; and from these the approximate death-rates shown in Fig. 8 have been calculated. The estimates of population in 1870 and 1871 are necessarily dubious, and it may be well to state, therefore, that the number of deaths from small-pox in 1870 was 10,331; in 1871 it was 2,777. The nearest approach to these totals was 2,193 in 1825 and 2,158 in 1880.

The Years intervening between successive Epidemic Peaks were—
3, 2, 4, 2, 1, 2, 1, 4, 4, 1 (?), 4, 5, 3, 6, 6, 6.

SCANDINAVIA.

In the first report of the Royal Commission on Vaccination[8] is given a statement of the annual number of deaths from small-pox in *Copenhagen*, 1750-1850, from which I have calculated the approximate death-rates given in Fig. 9. The number of deaths from small-pox in certain years in the eighteenth century was almost incredibly great; thus, 24 per 1,000 of the

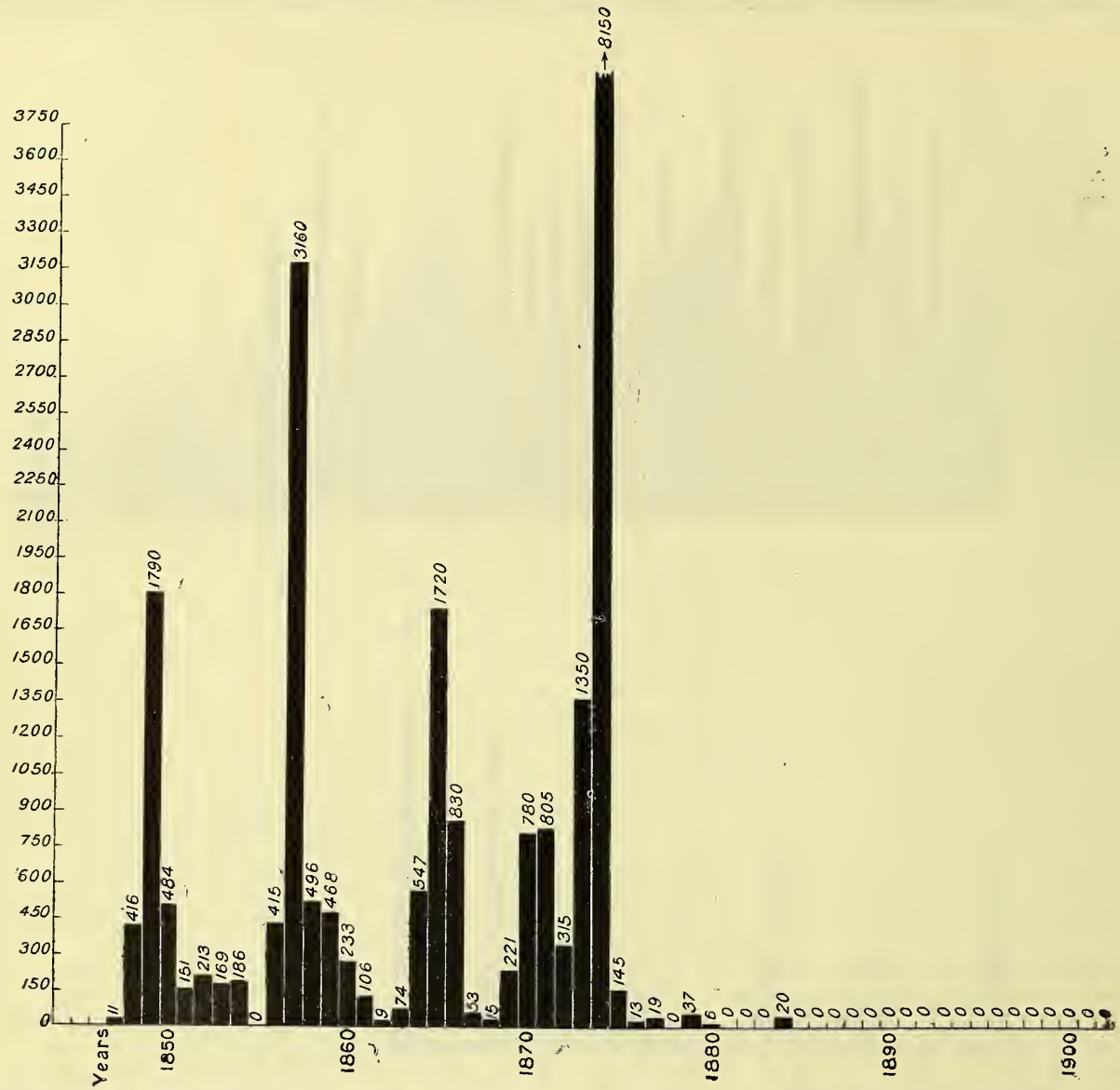


Fig. 15.—Annual death-rate from small-pox per million in Stockholm, 1847-1902 (Note.—Owing to an oversight this diagram has been drawn on a larger scale than the other diagrams for death-rates).

population in 1750, 18 per 1,000 in 1755, and 17 per 1,000 in 1769.

The Number of Years intervening between Successive Epidemic Peaks was—

1, 2, 4 (?), 3, 4, 3, 1, 3, 2, 2, 2, 3, 1, 2, 2, 3, 6, 15, 1, 2, 5, 7, 5.

I am unable to give the statistics for Copenhagen from 1850 onwards, but the following figures for the chief towns of Denmark [9] indicate roughly the cycles of the disease. The figures outside the brackets are cases of, inside the brackets deaths from, small-pox.

From 1870 to 1889 inclusive the Annual Number of Cases and Deaths was—

1,791 (58), 1,179 (60), 4,426 (275), 893 (40), 640 (70), 2,924 (225), 292 (20), 61 (5), 19 (1), 69 (2), 41 (3), 157 (5), 148 (12), 44 (4), 19 (0), 138 (23), 9 (0), 4 (0), 4 (0), 29 (3).

For *Christiania* I have been able to extract from the annual statistical returns the material (unfortunately two years are missing) for giving in Fig. 10 the death-rate from small-pox from 1860 to 1893 inclusive.

The disease in recent years has become almost extinct, the death-rate being almost too infinitesimal to show on the diagram. The first interval between epidemic peaks is four years.

AMERICA.

For purposes of comparison, the statistics for some American cities will now be given.

In *Boston* (p. 200, Appendix No. 3 to 3rd Report Royal Commission on Vaccination) there had been in the eighteenth century a high death-rate from small-pox. Thus it was 7,700 per million of population in 1721, 3,600 in 1752, and 1,000 per million in 1792. In 1811 the deaths from small-pox were 60 per million, no deaths 1812-14, 115 per million in 1815, no deaths from 1816 to 1823 inclusive. From that time onwards the maximum death-rates from small-pox occurred in 1831 (about 60 per million), in 1837 (160 per million), in 1840 (1,230 per million), in 1846 (810 per million), in 1850 (1,400 per million), in 1855 (1,120 per million), and in 1860 (about 1,100 per million).

For other American cities, the following more recent statistics are given:

In *Montreal*,[10] after a protracted and very severe epidemic in 1876-80, the intervals between epidemic peaks, which except the peak in 1885 are very small, were 4 and 10 years successively.

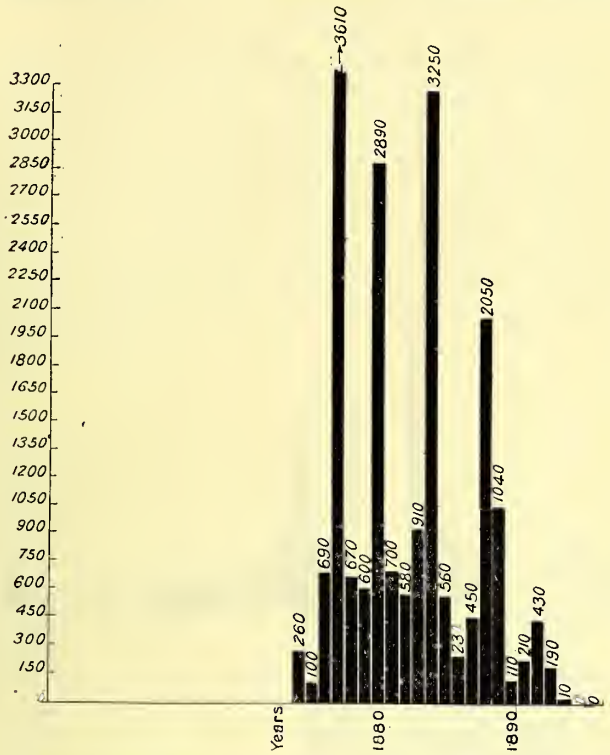


Fig. 6.—Annual death-rate in Prague from small-pox per million inhabitants, 1874-76.

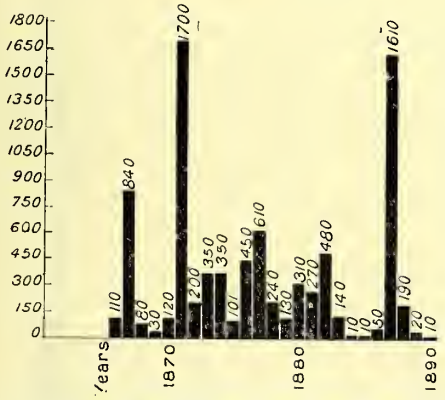


Fig. 7.—Annual death-rate in Florence from small-pox per million inhabitants, 1866-90.

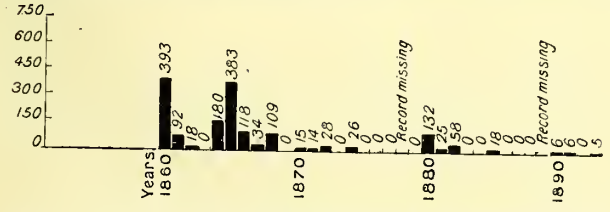


Fig. 10.—Annual death-rate in Christiania from small-pox per million inhabitants, 1860-93.

In *Chicago*[11] the successive intervals were 7, 3, 3, 9, and 11 years.

For the two South American cities from which I have obtained statistics—Rio de Janeiro and Mexico—only actual deaths can be given, no population figures being to hand. The figures for Rio are obtained from App. No. 15, (p. 742, 6th volume of Report Royal Commission on Vaccination) and those for Brazil from p. 751 of the same appendix. It will be noted that in Rio the years intervening between epidemics are 2, 1, 2, 1, 4, 4, 3, and 1 in succession; and that in Mexico they are 2, 4, 2, 3, and 4 in succession.

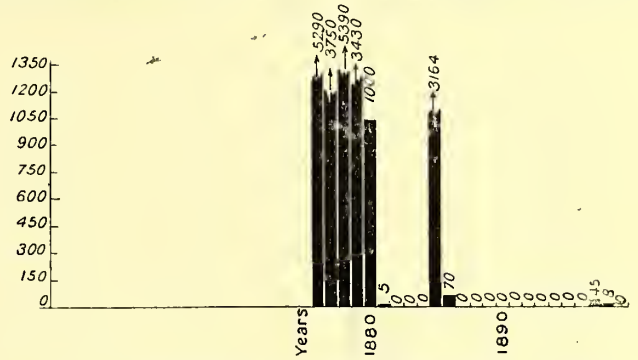


Fig. 11.—Annual death-rate in Montreal from small-pox per million inhabitants, 1876-99.

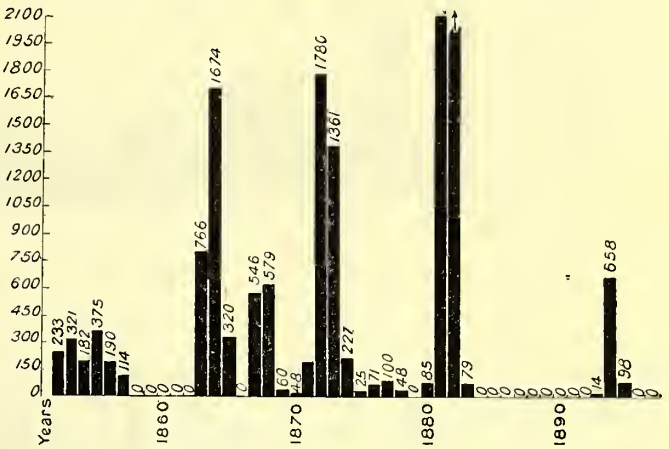


Fig. 12.—Annual death-rate in Chicago from small-pox per million inhabitants, 1862-97.

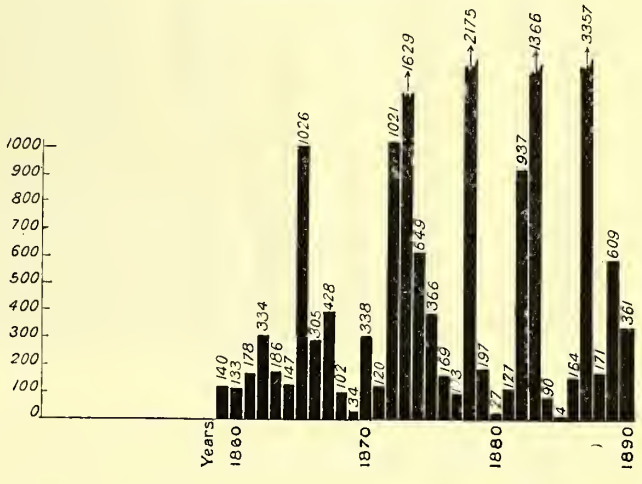


Fig. 13. Annual deaths from small-pox in Rio de Janeiro, 1859-1890.

MAJOR EPIDEMICS AND PANDEMICS OF SMALL-POX IN THE NINETEENTH CENTURY.

The diagrams contained in this communication being all drawn to scale and based (except Figs. 3, 13, and 14) on death-rates per million of population, it is now practicable to com

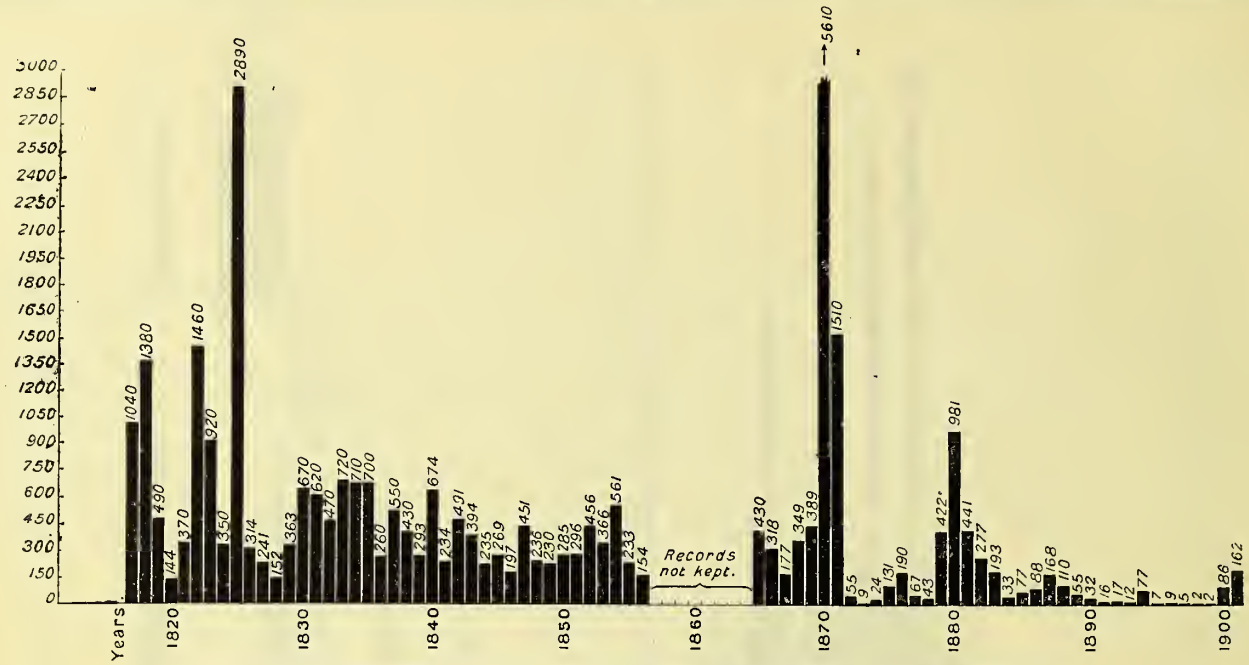


Fig. 8.—Annual death-rate in Paris from small-pox per million inhabitants 1817 1856 and 1865-1901.

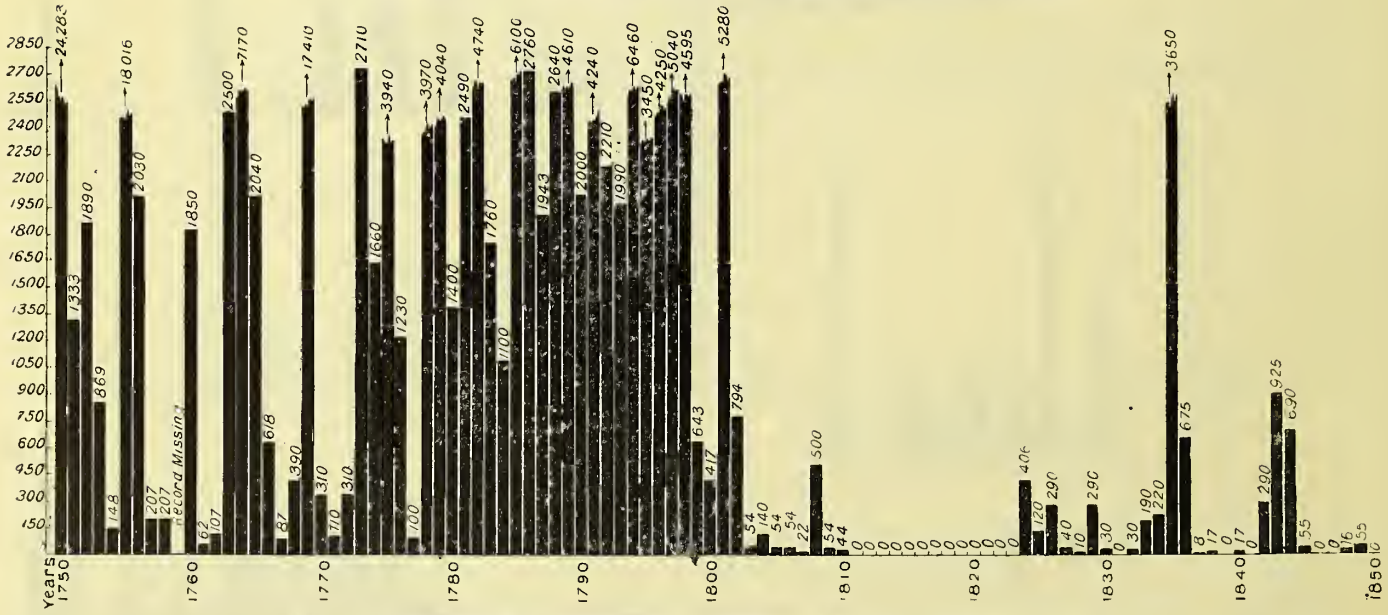


Fig. 9.—Annual death-rate in Copenhagen from small-pox per million inhabitants, 1750-1850.

pare them with each other and ascertain whether, so far as the greater epidemics are concerned, special years are common to any number of them.

It will be convenient to confine the comparison in the first instance to the nineteenth century. In London exceptionally severe epidemics occurred in 1838 and 1871. These epidemics are puny contrasted with the experience of the two preceding centuries, but they are severe when contrasted with other years of the last three-fourths of the nineteenth century. In Glasgow no such outstanding epidemic appears, the great peak of 1871 in London being replaced by a smaller and more protracted epidemic lasting four years (1871-4).

In Hamburg epidemics of exceptional magnitude are visible in 1824, 1842, 1864 and 1871.

In Florence 1871 and 1887 showed such exceptional epidemics. In Prague similar epidemics occurred in 1877, 1880, 1884, and 1888; in Paris in 1825 and in 1870-71; in Copenhagen in 1835; in Danish towns in 1872; in Christiania, not at all; in Stockholm in 1857, 1865, and 1874. In America such exceptionally great epidemics occurred in Montreal in 1876-80 and in 1885; in Chicago in 1864, 1871-2, and in 1881-2; in Rio de Janeiro in 1872-3, in 1878, and in 1887; in Mexico in 1872 and in 1877.

The Pandemic of Small-pox in 1870-73.

Notwithstanding the admirable report by the late Dr. Seaton,[12] which gives a large amount of valuable information, a complete account of the second pandemic of small-pox in Europe in the nineteenth century—that of 1838 being the first—is still a desideratum. In England the epidemic began towards the close of 1870, and terminated in

the second quarter of 1873. In France it seems to have begun about a year before it manifested itself in the United Kingdom,[13] in the last quarter of 1869 having already made considerable progress in Paris (see Fig. 8). Until near the end of 1870 there was, according to Dr. Seaton, "very little extension beyond France.....except in so far as it was directly conveyed by French prisoners to various places in Germany." During 1871 England and Scotland, Holland, Germany, Italy, and Spain "felt the full force of the epidemic," and in Ireland, Denmark, and some other European countries the first beginnings of its ravages were experienced. It also spread during this year to various places in Africa, to the West Indies, and to North America. During 1872 it invaded Austria, Russia, etc., South America, and other parts. By the middle of 1873 "the pandemic extension of the disease in Europe may be considered to have terminated."

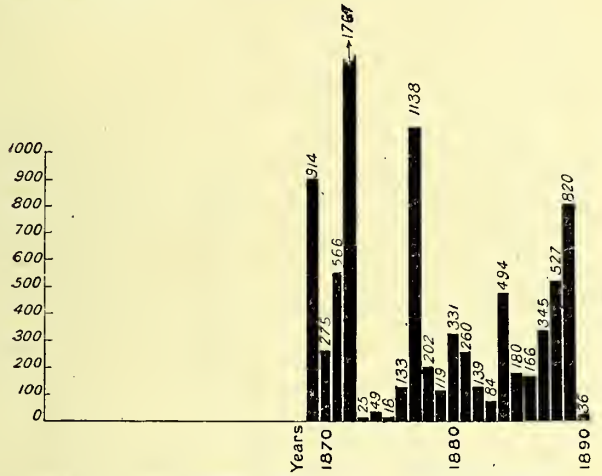


Fig. 14.—Annual deaths from small-pox in Mexico, 1868-90.

Comparing the preceding sketch with our diagrams, the following points are noteworthy. Glasgow suffered very little as compared with London, its epidemic beginning a year later than that of London. In Paris, during 1870, 10,331 deaths, and in 1871, 2,771 deaths, were caused by small-pox. The death-rates for these two years (Fig. 8) are given on populations estimated in the usual way; but this estimate is comparatively untrustworthy in view of the operations of the war and the siege of the city. In Hamburg, 83 deaths from small-pox occurred in 1870 and 3,647 in 1871. Florence also suffered chiefly in 1871. The figures for Prague do not go back to 1870. In the chief towns of Denmark (p. 22) there was some excess of small-pox in 1872, but on a comparatively small scale, and Dr. Seaton[14] remarks that Sweden during the years 1870-1872 appears to have been little affected by the epidemic then ranging over the greater part of Europe. He adds "there had been, indeed, an epidemic in Sweden during the quinquenniad 1865-1869, and this in 1870 was apparently on the decline." Fig. 10, dealing with Christiania, appears to me to throw considerable further light on the same point. This city had an epidemic of small-pox, culminating in 1865. Sweden, Dr. Seaton states, suffered similarly in 1865-1869. Paris was already suffering severely in the latter part of 1869. It is likely, therefore, that the infection spread southward to Paris in connexion with the enormous movements of population at the early part of the war, the infection thence spreading through France and Germany to the rest of Europe. Be this so or not, Stockholm in 1874 suffered from the pandemic to an enormous extent. At the time when Dr. Seaton's report was written, the Swedish statistical returns for 1874 were almost certainly unavailable. Whether the conditions of warfare played any part in increasing the virulence and infectivity of the disease must remain a matter of surmise. That it increased inter-communication between France and Germany, while at the same time the possibility of precautionary measures, whether of isolation or vaccination, was diminished, is without doubt. In London, as Dr. Edwardes points out, the death-rate from small-pox in this epidemic was not quite equal to that of the yearly average in the eighteenth century.[15]

Major Epidemics in the Eighteenth Century.

In the nineteenth century the influence of vaccination introduces fallacies in judging as to the intervals between epidemics and as to their magnitude. In the eighteenth century the amount of endemic small-pox is so great as to render it difficult to decide what shall be regarded as a major epidemic of the disease.

An inspection of the diagram of London's experience (Fig. 3) shows major epidemics from 1658 to 1680, at intervals of eight, five, and six years successively. The next interval is only three years; and then it may fairly be considered that, although an enormous endemic prevalence continues, an interval of twenty-four years elapses before the next great epidemic in 1710 occurs. Thence to 1740 a rapid succession of epidemics occurs. In 1752, in 1763, in 1772, in 1781, and in 1796 major epidemics recur.

In Copenhagen the greatest epidemics were in 1754, in 1768, in 1785, and in 1794.

Periodicity of Small-pox.

In describing the experience of the cities to which Figs. 2 to 14 relate, the intervals between each successive epidemic peak have been given. In the two preceding paragraphs the intervals between major epidemics in the eighteenth and nineteenth centuries have been roughly indicated. The most prominent feature is the shorter interval between the major epidemics in the earlier century. In London an interval of thirty-two years occurred between the great epidemics of 1838 and 1871, and an almost equal interval has occurred between the last-named epidemic and the epidemic now prevailing in London. The latter at present shows no evidence of becoming a major epidemic; but it is conceivable and indeed probable that it is so potentially, its power of spread having been dwarfed by the greater protection of the population by vaccination.

In Paris the interval between the two great epidemics of 1825 and 1870 is 45 years. The epidemic of 1901 was only small. In Copenhagen 34 years intervened between the major epidemics in 1801 and 1835. The preceding instances do not justify the assumption that there are "larger as well as smaller disease waves" *of a definite length* in the case of small-pox. It is unjustifiable to dogmatize on the strength of one or two coincidences. There is no sufficient evidence to justify the idea of a 30-years' periodicity for small-pox. What is quite certain is that with the extension of vaccination the intervals between epidemics have been increased, in addition to their magnitude being greatly reduced. Along with this has come a marked alteration in the proportion of deaths from small-pox which occur at different ages. This alteration does not show in the statistics used in this article.

"Epidemic Influence."

Are we then to assume with Hirsch (page 20) that the only factors determining the occurrence of an epidemic of small-pox are the introduction of the infection and the presence of a susceptible population? This might explain the recurrent epidemics on a small scale, and the greater interval between and the diminished scale in recent years of these smaller epidemics. It does not, however, explain the greater epidemics of, say, 1838 and 1871 in London. There would appear to be some additional cause at work to produce these greater epidemics (great in comparison with the epidemics in this century, puny when compared with the epidemics of the seventeenth and eighteenth centuries). Dr. Seaton remarks,[16] "What was the mysterious 'epidemic influence' which caused such peculiar intensity of the disease at this particular time is quite unknown to us." He points out how the peculiar intensity of this epidemic, and probably, it may be added, of all other greater epidemics, was manifested (*a*) by the extreme diffusiveness of the disease, (*b*) by its attacking in unusual proportion persons who were regarded as protected against the disease whether by previous small-pox or by vaccination, and (*c*) by the occurrence with quite remarkable frequency of cases of a malignant and haemorrhagic type, and a consequent high ratio of deaths to attacks.

Possible Relationship of Small-pox to Climatic Condition

So far as I am aware, Mr. Baldwin Latham is the only

person who has definitely stated that there is any connexion between climatic conditions and the occurrence of small-pox.[17] He remarks:

Small-pox is always preceded by a long period of dryness of the ground, measured by the absence of percolation. It should be noted that with reference to the year 1871, which was a very fatal year, the smallest amount of percolation on record occurred.

He goes on to state that:

In the autumn of 1870 small-pox commenced in Croydon after a very dry period, and continued up to the autumn of 1871. In 1876 an outbreak occurred after a very dry period, and continued until the autumn of 1877, and exactly the same conditions accompanied the outbreaks of 1881 and 1882, 1884 and 1885. It is quite clear that small-pox only occurs after intense dryness of the ground. Since September, 1885, there have been no deaths from small-pox recorded in Croydon, but during the whole of that period (five years) there has been but one month when no measureable quantity of water percolated through a gravel-percolating gauge 1 yard deep, and that was in October, 1886, a period when the ground was naturally moist; but in 1884, when small-pox last broke out, it was preceded by seven months in that year when no measurable quantity of water percolated through the sand gauge.

Mr. Latham, in conclusion, advances the statement that "it is almost absolutely certain that small-pox is propagated in the same way as cholera and other diseases under the peculiar conditions to which I have drawn attention." As small-pox has never been shown to be and is almost certainly not waterborne this statement requires extensive modification; for enteric fever and cholera, in this country at least, are when occurring in great epidemics chiefly waterborne. It is furthermore difficult to conceive how the unknown microbe causing small-pox, which appears, so far as all the available evidence goes, to be solely parasitic, can be affected by conditions of the soil. Such a hypothesis appears to involve the assumption of an extra corporeal stage of existence of the microbe of small-pox. It appears furthermore to imply that the first cases of small-pox in an epidemic need not necessarily be directly connected by importation and infection with preceding cases. And yet it is most exceptional to be unable to trace the exact importation of the infection of small-pox, and in these exceptional cases the possibilities of importation have not been exhausted.

Without attempting to frame a hypothesis which will meet the conditions of the problem, we may inquire whether the conditions named by Mr. Baldwin Latham have always been present during other great small-pox epidemics, and whether in their absence these great epidemics have never occurred.

Mr. Latham lays special stress on the absence of percolation of rainfall through the soil, which is not necessarily, though usually, proportional to the smallness of the annual rainfall. In the absence of other available data I must take the latter criterion, comparing it with the metropolitan death-rates from small-pox. The year 1714 was a remarkably dry year (Latham). Fig. 3 shows an epidemic peak in that year, which was not so high as the peaks of other years before and after it. The year 1742 was again dry (Latham) but there was less small-pox than usual.

The year 1825 was remarkable for its entreme dryness,[18] and small-pox was excessive in amount. In 1838 a major epidemic of small-pox occurred in London. The rainfall in London in this year was about 85 per cent. of the average rainfall, the deficiency occurring almost entirely in the first five months of the year (Sowerby Wallis).

The year 1871 (a major epidemic year) was the third of three successive years of deficient rainfall. In each year 1854-58 there was a very deficient rainfall, but very little excess of small-pox.

Taking next wet years: 1829 was very wet; small-pox was above the average of the neighbouring years. The years 1859-60 were wet; small-pox was above the average amount. In 1877 excessive rainfall and excessive small-pox coincided. On the whole, it is clear that no general rule can be laid down, though small-pox is more common in dry than in wet years.

Brückner's Cycles.

Brückner, after a very elaborate examination of the records of rainfall of the world, concludes that since 1700 at least, most of the land surface of the earth has been subject to a recurrence of cold and wet, alternating with warm and dry periods, the somewhat variab e interval between the middle of two succeeding periods being about 35 years. Bacon, in his *History of the Winds*, remarks "it has been observed by the diligence of some that the greater and more remarkable seasons of the weather, as great heats, great snows, great frosts, warm winters, and cold summers, generally came round in a circuit of 35 years."[19]

The periods of alternating excess and deficiency of rainfall given by Brückner are shown in the following table, in which the aggregate and average number of deaths from small-pox in London during each period are also given.

Wet Period.	No. of Deaths from Small-pox.		Dry Period.	No. of Deaths from Small-pox.	
	Total.	Annual Average.		Total.	Annual Average.
1691—1715	32,419	1,297	1716—1735	43,726	2,186
1736—1755	39,263	1,963	1756—1770	35,188	2,346
1771—1780	20,923	2,092	1781—1805	42,893	1,716
1806—1825	17,823	891	1826—1840	9,624	642
1841—1855	12,781	852	1856—1870	11,332	755
1871—1885	21,127	1,408			

In interpreting this table, it is to be remembered that deaths, and not death-rates are given, and that the general European periods of wet and drought do not necessarily hold strictly good for England. Bearing these points in mind, and making an allowance for increase in population, it will be seen that only from 1691 to 1770 does the relationship between dry periods and excess of small-pox hold good. It is possible it would have held good from 1771 to 1805 had it not been for the great reduction in the mortality from small-pox which followed the introduction of vaccination at the end of the eighteenth century. In the nineteenth century no inverse correlation between the amount of rainfall and of small-pox is perceptible.

Conclusion.

A careful study of the preceding diagrams and of the history of the different epidemics makes it clear that the chief governing factor is personal infection; that the disease spreads from town to town, and from one country to another, not always affecting different countries in the same year, as it might be expected to do when similar climatic conditions occur in the different countries if climatic conditions had a predominant influence. There is, however, some further factor responsible for the causation of the greater epidemics and pandemics of small-pox, which, for lack of a better term, we must still designate by the old-fashioned name of "epidemic constitution." As the expression of a fact, without being committed to a theory, we may admit with the older epidemiologists that there is a *constitutio epidemica variolosa*. What is meant by this is that at certain irregular intervals small-pox, as judged by its wider spread, is more infectious than it is in other years with equal opportunities for its dissemination. There is no regular periodicity for these greater epidemics; but there is a fairly regular periodicity for the minor epidemics, which has become disturbed and the intervals protracted in well-vaccinated communities.

Whether small-pox belongs to the group of diseases including scarlet fever, diphtheria, and rheumatic fever, which have been shown to become epidemic chiefly in years of deficient rainfall, is open to doubt; but the statements already quoted on this point deserve fuller investigation than they have hitherto received.

References.

[1] Third Vol., Report, Royal Commission on Vaccination, App. II, p. 196. [2] Second Vol., Report R. C. V., App. X (to Dr. Creighton's evidence), p. 288. [3] Stevenson and Murphy's *Hygiene*, vol. ii, opposite page 433. [4] *Geographical and Historical Pathology*, New Sydenham Society, vol. i, p. 145. [5] Op. cit., p. 582. [6] From Dr. Jahor's Report on Prague for 1893-96. [7] From paper by Dr. Leonida Castelli, vol. i, *Transactions* Seventh International Congress of Hygiene and Demography, p. 188. [8] Vol. i, App. I, R. C. V., p. 107. [9] From *Denmark: its Medical Organization and Demography*, 1891. [10] From Dr. Laberge's Annual Report for 1899. [11] From Dr. Reynolds's Annual Report for 1897-8. [12] Reports of the Medical Officer of the Privy Council and Local Government Board, New Series, No. 4 (1874), p. 51. [13] Op. cit., p. 51. [14] Op. cit., p. 61. [15] Op. cit., p. 80. [16] Op. cit., p. 57. [17] The Relation of Ground Water to Disease, Presidential Address to the Royal Meteorological Society, No. 19, 1890. [18] Report of *Lancet* Sanitary Commissioners, 1859. [19] Quoted by A. B. Macdowall, M.A., *Knowledge*, March 1st, 1899, p. 54.

A CENTURY OF VACCINATION:

SMALL-POX EPIDEMICS AND SMALL-POX MORTALITY BEFORE AND SINCE VACCINATION CAME INTO USE.

BY E. J. EDWARDES, M.D., M.R.C.P.LOND.

As the title indicates, the subject here considered is the mortality from small-pox during the nineteenth century—a century of vaccination—as contrasted with previous small-pox mortality before vaccination was in use, with especial reference to epidemic outbreaks of the disease.

A word on statistics before going further. When a person dies of small-pox that death and its cause are unmistakeable; the whole surrounding community is aware of the solid fact that the person is dead of small-pox. A hole is made in the ground and he is buried, and the death is noted amongst the other deaths by local officials and reported to the central Government. From time to time the latter furnishes statements as to the number of these deaths and the localities, and perhaps the ages, of the victims. Now educated people have airily remarked to the writer when such records have been mentioned, "Ah, but you know statistics can prove anything." Therefore be it known that the only manipulation of official records in this article is that the deaths in a population are stated as deaths per 1,000,000 of that population, and this is absolutely necessary for the purpose of comparison with other populations. You cannot say, because 4,000 deaths from small-pox occur in one year in a country, and 2,000 deaths in another country, that small-pox is twice as fatal in the former country, unless you state at the same time that their populations are exactly the same in number. Some standard of comparison is essentially necessary, and the number 1,000,000 is convenient.

The term "rate," then, unless otherwise specified, means here the number of deaths in one year from small-pox per million living in any given country, and the term "average rate" or rate during a given period means simply the average of the yearly rates during that period. The term "deaths" means deaths from small-pox unless otherwise specified.

Apparently, then, the question is merely a comparison of rates. But on the threshold of the subject we are confronted by this difficulty, that official "rates" are for the most part a product of the nineteenth century; for example, the official rate for England begins with the year 1838. Fortunately, one country in Europe, namely, Sweden, presents us with an official rate year by year since 1774, a quarter of a century before vaccination began.

Bills of Mortality.

Also we have records of the small-pox deaths and the total deaths year by year in various cities during various periods before vaccination began and onwards, so that we can state what proportion of the deaths from all causes was due to small-pox—the small-pox mortality will be given as a percentage of the total mortality, for the sake of comparison. These records are the parish burial records, also called "bills of mortality" and "church lists"; they are not, strictly speaking, "official" in the modern sense of the word, but they may be relied upon as far as they go. In other words, we may be sure that the recorded deaths actually occurred, and that they were small-pox deaths, though possibly not all the small-pox deaths. We possess such records for London (from 1629 onwards), also for Geneva (from 1580), for Berlin, and some other cities. In the case of Kilmarnock, careful records were kept by a schoolmaster.

Sweden.

The average rate for Sweden during the period 1774-1800—that is, before vaccination began—is 2,049; while during the period 1802-11 (vaccination began in 1801) the rate sank to 623; during the period 1812-21 (vaccination was made obligatory in 1816) the rate sank to 133, and the average rate for the ten recent years 1890 99, with much improved vaccination, is only 1. Thus the rate has been brought down from 2,049 to 1. The actual deaths from small-pox averaged 4,410 yearly in the prevaccination period, while in the last decade the number is almost insignificant.

The rate for Sweden in the prevaccination era—namely, 2,049—is the rate for a scanty and scattered and comparatively isolated population. In other countries and in all large cities the rate was much higher, being about 3,500 yearly per million living in Copenhagen during the latter half of the eighteenth century, about 4,000 in the third quarter of that century (1750-75).

Prussia.

So far we are on solid ground. But the following rates in the prevaccination era are not officially vouched for, namely: Prussia about 4,000, England about 3,000, London above 4,000. In a dispatch dated October 31st, 1803, King Frederick William III stated, on the authority of the Medical College, that small-pox annually cost Prussia on an average 40,000 lives; now the Prussian Statistical Bureau gives a population of 10,023,900 in the year 1804, thus the above rate is amply justified. The London estimate is by Dr. Farr, a sound statistician, who was a master in the subject. During the ten recent years, 1889-1898, the average rate for Prussia, with compulsory revaccination of all school children, as well as compulsory vaccination in infancy, is 2, in place of 4,000, and for the German empire is only 1.4. Instead of losing 4,000 lives per million of population each year, Prussia loses 2 lives per million by small-pox. Vaccination has done this. If Prussia were the only country under consideration we could not assert that vaccination is the sole cause of this extraordinary lowering of small-pox mortality to almost *nil*. But we know that vaccination is the sole cause, because neighbouring countries which have not adopted vaccination so thoroughly as the German empire since 1874 show still a high mortality from small-pox. During only five recent years—namely, 1893-97, the Russian empire has lost 275,502 lives by small-pox alone, which gives a rate of 463 yearly; Austria, 11,799 (rate 99); England, 3,066 (20); Belgium, 3,208 (100); Hungary, 12,241 (134); Spain (four years), 23,881 (563). So strict is the correspondence between the amount of vaccination and the *small-pox rate* that if we know the vaccination laws of any country in Europe for about twenty years, and also how they are carried out, we can guess very closely the average small-pox rate of that country.

As an example, the Imperial Health Office in Berlin has contrasted three countries having obligatory vaccination in infancy with three countries without such obligatory vaccination, in the period before Prussia had compulsory vaccination. The three former countries are: Bavaria in the period 1844-69; England, 1853-69; and Sweden, 1844-69. The three latter are Prussia, 1844-69; Austria, 1847-69; and Belgium, 1851-69. The average rates of the former are 85, 167, and 189, and of the latter 248, 272, and 273, in the order given. The very close agreement between the three latter rates must strike the reader; these three countries concerned agree in that vaccination was encouraged by the State but not made obligatory on all, while the three other countries have each a much lower rate. A similar contrast will appear when we come to discuss the epidemic of 1871-3. Again, the German Empire adopted compulsory vaccination and compulsory revaccination in the year 1874, and Germany was the only country in Europe till the last decade or nearly so which adopted vaccination in this way. Thus Germany differed from the other neighbouring countries, Austria, Russia, France, in having a rigorous vaccination law. As regards all other conditions the countries remained very much the same as before. But suddenly an enormous and persistent reduction appeared in the rates for Prussia and Bavaria and other countries of the German Bund, while the rates for France, Austria, and Russia remained very high.

Lastly, if we take any one country, we find that the small-pox rate is lowered *pari passu* with the degree in which vaccination is utilized. The Prussian rate before vaccination began was estimated as about 4,000; during the decade 1854-63 it sank to 224, while for the ten years 1889-98 it is only 2. Again, the average rate in England in the eighteenth century has been estimated by competent men as not less than 3,000, in London it was much higher; during 1847-53, with vaccination non-compulsory the rate is 304; during 1857-66 with vaccination obligatory but not enforced the rate is 200 (in round numbers); for the period 1872-1900, with enforced vaccination, the rate is 70, while for the period 1873-1900,

which gives time for the Act of 1871 to get into operation, the rate is a little over 40, which is forty times as high as it need be. If we had compulsory revaccination of all school children in the United Kingdom our rate would be even lower than the German rate, which is now a little over 1, because we are surrounded by the sea and not by deficiently vaccinated populations, as is Germany. Thus if we apply the so-called Canons of Induction in our reasoning as was first done in the work—*Vaccination and Small-pox* (London: Churchill, 1892), we find that whether tested by the method of agreement, or the method of difference, or by the method of concomitant variations, that is, increase of effect *pari passu* with increase of supposed cause, the proof becomes irresistible that vaccination is the cause of the lowering of the small-pox mortality rate, which we have seen to occur.

London.

Now we pass on to obtain a view of the state of things before the vaccination era. Bryce, quoted in a work by Monro (Tertius) published in 1818, wrote this:

If we allow that 40,000 persons die annually from small-pox, *and that is 1 in 14 of all that are born in these countries*, then 40,000 × 14 gives 560,000 persons born.

Thus, Bryce actually uses the mortality from small-pox in the United Kingdom as a means of estimating the number of births, so steady was the mortality. In fact, before the introduction of vaccination small-pox was always with us. It was endemic in every large city, and appeared with great regularity every four or five years in small towns. Taking London as an example, the steadiness of the mortality is shown by the following deaths in each year of one decade 1681-1690, namely, 2,982, 1,408. 2,096, 1,560, 2,496, 1,062, 1,551, 1,318, 1,389, 778. The population of London was then about half a million, probably less, and the above mortality would now be represented by about 15,000 deaths every year in London alone. The total deaths in the decade were 223,606, thus the small-pox mortality was $\frac{1}{13}$ of the total mortality. The average for the eighteenth century is $\frac{1}{12}$.

To show the regularity of recurrence of epidemics in country towns we have the remarkable example of Boston, Lincs. The following are the small-pox deaths year by year for half a century:

1751-60:	0,	0,	0,	1,	19,	**34**,	4,	4,	0,	2
1761-70:	0,	3,	**69**,	5,	0,	0,	0,	0,	3,	**78**
1771-80:	2,	6,	**27**,	0,	**55**,	7,	6,	**18**,	3,	0
1781-90:	**19**,	0,	0,	**58**,	4,	0,	0,	0,	**27**,	0
1791-1800:	2,	0,	1,	0,	1,	**64**,	0,	0,	0,	1

Only the children were attacked, the adults had all gone through it. Directly the susceptible element of the population—namely, those born since the last epidemic—acquired any significance, back came the destroying angel. No figures show this so clearly as the figures for Kilmarnock for 36 years of the eighteenth century, as elucidated by Dr. McVail from the careful records of the schoolmaster Robert Montgomerie, who was also sessions clerk.

Kilmarnock.

The following figures, which represent the mortality from small-pox in Kilmarnock for the 36 years 1728-64, are instructive:

The estimated population was 4,200; the births, 4,514; the total deaths, 3,860: the small-pox deaths, 622. Thus the latter are nearly one-sixth of the total deaths, an exceptionally high proportion. The proportion for London during each decade of the eighteenth century averages $\frac{1}{12}$. During the 36 years there were 9 epidemics; they recurred, "with terrible regularity," about every four years, with the following deaths: 66, 45, 66, 66, 74, 84, 95, 46, 66; besides which there were a few deaths in the intervening years.

Now for the most remarkable fact as regards all these epidemics. *Of the 622 persons who died, 586—nearly all—were under 6 years of age;* 27 were aged "6 years and older," and of 9 the age is not known. In the present day no undoubtedly vaccinated children die of small-pox; those who die are unvaccinated children, together with unvaccinated adults and a few vaccinated adults who perish because their vaccination protection has lapsed by time, and has not been renewed by revaccination. In London during 1892-3 Dr. Luff reported to the Royal Commission *110 attacks in undoubtedly vaccinated children under 10 years, with not one death*, while of 228 unvaccinated children attacked, 61 died (27 per cent.). And in Gloucester in 1892-3, while 279 children under 10 died of small-pox, there was only 1 death in a vaccinated child under 10, and that case was an exceptional one; the vaccine crusts were still on the child's arm when she was infected.

The Slaughter of the Innocents.

In former times the age-class under 10 years furnished nearly all the deaths. Thus in Berlin, 1758-74, of 6,705 small-pox deaths, 5,876 under 5 years, 742 aged 5 to 10 years—that is, 99 per cent. under 10 years; in Manchester (1769-74), of 589 who died, 559 were under 5 years; and in Warrington, in 1781, there were 209 deaths, 197 at ages under 5 years. These statistics prove the assertion made, and this change which has ensued since vaccination came into use is the most striking proof of the protection afforded by it. As a contrast, in well-vaccinated Sheffield in 1887-8, of 474 deaths at all ages, 368 were at ages above 10 years.

In Kilmarnock, taking a special year—1733—of the 45 children who died in that year, 44 were under 5 years, the remaining child was only 7 years old. Thus only 1 child that died in the epidemic of 1733 had been alive previous to the height of that of 1728. "The disease had to secure its victims almost wholly from the population that had come into existence since its last visitation. One epidemic left almost no victims for its successors, that is, no unprotected; in the same way hardly any had been left to it by its predecessors. The figures show that nearly nine-tenths of those who died in one epidemic had been born since the previous one, that one-tenth who died had passed safely through one epidemic, and that only 1 in 100 of those who died had lived through more than one outbreak" (McVail).

The Scourge of Humanity.

This, or something very like it, was the state of things in former times in every town in England, nay, all over Europe. The list of epidemics in Boston shows that this particular town must have closely resembled Kilmarnock. And travellers have recorded a still worse condition in Central Africa, where it is said that small-pox causes half the total deaths. Regarding India, Pringle wrote:

If cholera carries off hundreds every year (he might have said thousands), if the victims of famine were to be counted by thousands, these are but infinitesimal quantities beside the frightful devastation caused in India by small-pox.

In China and Thibet travellers have stated that small-pox caused an incalculable mortality; in Corea, Cheval found almost the whole population pock-marked. In fact, small-pox was the scourge of humanity; no age and neither sex was exempt; it spared not the palace or the throne at times in spite of the most rigid precautions. In a country like England adults were exempt from attack for the most part—they had gone through it in childhood, and the disease often left blindness behind, or maiming for life by contractions, or wasting illness, or dreadful disfigurement.

Ravages of Small-pox among Unprotected Populations.

But the reader will not gain an adequate view of the terribly destructive nature of small-pox until he has had some account of its ravages amongst unprotected populations—that is, where it appeared for the first time, or after a long interval of absence. In such cases it is no longer a children's disease, but a disease attacking all.

We learn that small-pox was known in Europe as early as the sixth century, being repeatedly imported from Asia Minor and Africa—for example, in 711 it followed the Saracens into Spain. In the Middle Ages, in Great Britain and Ireland the monkish chroniclers describe its contagiosity and fatality, its chief symptoms—the skin becoming ultimately black, with a dreadful fetor—and the blindness and contractions left behind. In the year 1270 the disease was well known in England.

Iceland was first invaded in 1241, a ship from Denmark having brought the infection, which in two years cost 20,000 lives in a scanty population. There were nineteen separate invasions by the disease in the prevaccination era, each time brought by ship. In 1707 an epidemic killed 18,000 out of a population of only 50,000. In one of these early invasions the disease extended to Greenland, and so ruined its small settlements that the existence of Greenland was forgotten

for three centuries afterwards. When fresh settlements were made the disease was conveyed there again in 1734, and it destroyed nearly two-thirds of the inhabitants, and Crantz (*History of Greenland*) gives an awful description of the desolation thus caused.

In the Netherlands the first accounts date from early in the tenth century. Countess Elfrida died of small-pox in 907, and Count Arnold of Flanders in 961; the term "variola" was used in his case. This term had previously been used in the sixth century by Bishop Marius of Avenches (Lausanne). It can be shown that "variola" always meant small-pox, for in 1648, a date when every one was familiar with the disease —no one will contest this—Salmasius wrote: "*Variolas quas ad distinctionem parvarum, magnas indigitamus*"—the pocks which, to distinguish them from the small, we term the great. It is erroneous to assert, as Dr. Creighton has asserted: "But the sixteenth century references to small-pox, although they are indeed scanty, are at the same time the earliest authentic accounts of it in Western Europe." The enemies of vaccination naturally want to minimize the ravages of small-pox.

In 1493 the West Indies were discovered, and the first outbreak of small-pox occurred there in 1507, imported from Spain, and it was so disastrous that whole tribes were exterminated by it.

In 1520 small-pox reached Mexico, through one small-pox patient in the army of Narvaez. Its ravages in that country and in South America are described in an article entitled "Small-pox before Jenner," which appeared in the "Jenner Centenary Number" of the BRITISH MEDICAL JOURFAL (May 23rd, 1896).

Now we turn to Europe again and try to ascertain how many severe epidemics of small-pox have occurred during the last century—the vaccination century as we may term it—and compare them with epidemics of the prevaccination era.

EPIDEMICS IN THE NINETEENTH CENTURY.

For nearly two decades after vaccination began—it began with the century as far as Europe is concerned—small-pox epidemics appeared to be on the point of dying out everywhere. But towards the end of the second decade they began to recur, with altered characters. They were never so extensive as of yore, and small-pox now attacked the vaccinated in increasing numbers as the years rolled by. From its mildness when it attacked the vaccinated the disease appeared as quite a new and strange disease, namely, modified small-pox, a disease which at first greatly puzzled able observers. But here and there deaths occurred in the vaccinated.

Now, there was one point on which the chief medical men, in this country especially, made up their minds, namely, that a single vaccination in childhood afforded permanent protection. Even when vaccinated persons died of small-pox they maintained their belief. Bryce wrote in 1818:

> There is no evidence to conclude that the protecting influence diminishes by time.

How then were cases, continually increasing, of small-pox in the vaccinated, to be explained? The majority said at first that it was owing to some peculiarity of constitution; some called the new mild disease chicken-pox. Thomson said "No, it is not chicken-pox, but small-pox," and then set to work to invent a theory that chicken-pox, small-pox, and the "new disease" were all due to the same contagion. Other theories were—imperfect vaccination, a really new disease; degeneration of vaccine lymph—while very few grasped the simple truth—namely, lapse of protection by time. Goldson was one of these few, as early as 1804. Bell, of Musselburgh, wrote in 1819:

> I think that.....while we continue to maintain (that) the antivariolous power of vaccination is perfect and permanent—contradiction, confusion, and obscurity attend the subject.

Gregory thought the protection lapsed in a certain percentage (35 per cent.) not in all. On the Continent a few also took the right view—Hodenpyl of Rotterdam, 1818; Elsässer of Stuttgart, 1820. Later on many others—for example, Wendt, Möhl, Robert, Heim, and especially Herder at St. Petersburg, 1823. Then gradually the era of revaccination began, at first in various German armies. In England, as late as 1851, the National Vaccine Establishment said that revaccination was as incorrect in theory as it was uncalled for in practice.

But the early epidemics of the century constituted a triumph for vaccination. Of Gibson's 251 cases of small-pox in the vaccinated, not one was fatal; and of Thomson's 310 cases, only 1 was fatal, the disease, as already stated, being so mild in the vaccinated, as a rule, as to be scarcely recognizable.

In the Norwich epidemic in 1819, out of 530 deaths, Cross on diligent inquiry heard of only 2 deaths in the vaccinated. In Marseilles, of 2,000 vaccinated cases, 20 were fatal, while of 4,000 unvaccinated cases, 1,180 were fatal (Favart). The reader must bear in mind, also, that the operation of vaccination in those early days was often very imperfectly performed.

Excepting these early epidemics in the last century, as to which we have only isolated accounts by different observers, we may say that there have been only two severe epidemic outbreaks of small-pox in England in the last century—namely, one in 1838, when the Registrar-General's statistics commence, and the other in 1871-2. The latter was by far the more severe of the two, the rate for England in 1871 being just over 1,000 per million, and it is the only great epidemic since compulsory vaccination began. But we have seen that in London, according to the official census, the average yearly rate in the last quarter of the eighteenth century was 2,000 in round numbers, and good statisticians have estimated the average rate for England in the century before vaccination at 3,000 (Sir Lyon Playfair's speech in the House of Commons). But if we only assume Sweden's rate—namely, 2,000—as the rate for England then *we should require to imagine an epidemic twice as severe as the terrible epidemic of 1871 to occur every year of the century* in order to represent to our minds the small-pox mortality of the era before vaccination was introduced.

Again, we have seen that in Kilmarnock the small-pox deaths during the 36 years, 1728-64 were nearly $\frac{1}{8}$ of the deaths from all causes. In Berlin the ratio was $\frac{1}{13}$, in London $\frac{1}{12}$, in Glasgow (1783-1800) as high as $\frac{1}{8}$. Let us call that year an epidemic year, in which the ratio is $\frac{1}{10}$, that is, when small-pox causes 10 per cent. of the deaths from all causes—a moderate assumption as regards the eighteenth century. Then, according to Dr. Guy (*Two Hundred and Fifty Years of Small-pox in London*. R.Stat.Soc. 1882.), in the 48 recorded years of the seventeenth century there were 10 epidemic years, giving about 20 epidemics for the whole century, in the eighteenth century there were 32, and in the nineteenth century there was not one. Thus the visitation of 1871-2, which caused 23,060 deaths out of 514,879 total deaths in this country was not worthy of the name of an epidemic beside the outbreaks of old.

THE EPIDEMIC OF 1870-5.

Now let us study the great epidemic of the century more closely. It was really a pandemic, and seems to have affected the whole globe, but we will study it where we have complete records, namely, in North and Central Europe. The rate in London for the year 1871 was 2,432—the epidemic raged far more severely in London than in the provinces—in Berlin it was as high as 6,326. Prussia had not then compulsory vaccination of all infants till 1874, In Hamburg the small-pox rate was 10,750 (!) in the year 1871, a rate that makes one shudder to think of.

1. At the time of the pandemic of 1870 the four countries (A) England, Scotland, Bavaria, and Sweden, enjoyed compulsory vaccination, while the following four countries (B) had not compulsory vaccination, namely, Prussia, Austria, Belgium, and the Netherlands. It will therefore be instructive to compare the rates of these countries in the order given, taking in each case the average of the six years 1870-5, for the epidemic was later in some countries than in others.

A. *Average Rates (1870-5) in Four Countries with Compulsory Vaccination.*

361	314	346	333

There is a most remarkable agreement between these rates; of Bavaria we shall have to make further mention later. Now we turn to the rates for the other four countries.

B. *Average Rates (1870-5) in Four Countries without Compulsory Vaccination.*

953	1,360	1,293	958

Thus the four latter countries show a mortality more than thrice that of the four countries with compulsory vaccina-

tion. In 1872 a law was passed in the Netherlands making admission to a school dependent on a vaccination certificate, but this does not affect the above comparison, because the chief force of the epidemic expended itself there in 1871 and 1872 (rates 4,355 and 1,021). The rate for Belgium in 1871 was over 4,000.

2. When we examine the age classes of those who died, as far as they are available, we find, as we might expect, that where compulsory vaccination existed, the chief mortality was borne by the age class "above 20 years," but where there was no compulsory vaccination the chief mortality was amongst children.

3. One section of the various populations of Germany was only very slightly affected. That section was the German field army, numbering over a million men, though more exposed to the contagion than any other part of the population, for the epidemic raged with the greatest virulence in France. The total small-pox loss of the German field army was only 297. On the other hand, one small garrison town in France lost more than this, namely, 334. Now we know that the German field army was well vaccinated except as to some levies hastily raised, while it has been proved that the French army was very deficiently vaccinated.

4. But perhaps Bavaria, a well-vaccinated country ever since 1807, as far as regards vaccination in infancy, affords us the most valuable lesson of the epidemic, for *England is now where Bavaria then was as regards vaccination.* Thus the whole population of Bavaria had for the most part been vaccinated in infancy, and some had been revaccinated. Therefore nearly all the small-pox attacks occurred in the vaccinated.

In Bavaria: 30,742 were attacked, of whom 29,429 were vaccinated persons.

The English nation seems disinclined to face this great fact, but it has got to be faced. The Bavarians after this—nay, all Germany—saw that once-vaccination was utterly insufficient to prevent severe outbreaks from spreading when once they get a start. "It only showed," said Koch in 1884, "that the vaccination which we formerly had was insufficient, and that it had to be completed by revaccination." The experience of the German army had conclusively proved the necessity and value of revaccination, and an Imperial Vaccination Law was passed in 1874, making vaccination in the second year of life, and also revaccination in the twelfth year of life of all school children, compulsory throughout every nation belonging to the German Bund—Prussia, Bavaria, Saxony, Baden, etc.

German Revaccination Law of 1874: Results.

The result is said in a few words—*small-pox epidemics have been abolished altogether in Germany.* The rate is almost *nil.* The few deaths which occur are due chiefly to importation from Russia and Austria.

German Mortality in 1899.

The reader will see the importance of the following:

In the year 1899 not a single death from small-pox occurred in any large town of the whole German Empire, numbering 54 millions. There were 28 such deaths in all, giving a rate of 0.5. These 28 deaths occurred chiefly nearly the frontiers; and, lastly, *the 28 deaths occurred in 21 separate districts* and yet no local epidemic was started. This is very significant.

England since the Epidemic of 1871-2.

England in 1871 created a machinery by which to put in force the law of 1867, and trusted to rigorous vaccination of infants at a very early age—3 months. It was left to Boards of Guardians to initiate prosecutions for default, and no attempt was made to instruct the nation. Once-vaccination is utterly insufficient. Local epidemics arose from time to time, while the law was harshly administered when set in force, hence some Boards of Guardians revolted altogether, and their number steadily increased. Then Government in its wisdom had a Royal Commission of gentlemen appointed, who knew nothing about the subject for the most part; very few of them had ever studied the question of vaccination and small-pox. Like true Britons, they almost ignored the experience of other countries, and set to work to get up the subject at first hand for themselves in the most conscientious and painstaking manner. But this took a long time, and while they were at it several severe local epidemics occurred. Accordingly they sent out medical men to study local epidemics, and then went on with their antiquarian topics, discussing John of Gaddesden and the origin of Jenner's second stock of lymph, and Woodville's variolous cases. At last came the Gloucester epidemic, which shook in their shoes the members of the Royal Commission, and after their seven long years of labour they issued their report, which in its legal phraseology is well known to all. They could not help concluding that revaccination is necessary, but they had not the courage to recommend Parliament to make it the law of the land for all school children, and even surrendered compulsory vaccination in infancy. The German Commission of 1884 consisted of eighteen members, all medical men and expert in the subject, with a lay chairman. Their eight chief conclusions are a model of conciseness.

The statistics of the local epidemics published in the Royal Commission's report have been repeatedly put before the public, and need not be reproduced here.

This article may fittingly conclude with a very remarkable fact, which shows that revaccination must be made universal and not left optional if we want to utilize the beneficent protective action of vaccination to the full. The German law of 1874, which imposed vaccination and revaccination on all, made no difference to the German army as regards its vaccination. This army had already enjoyed revaccination ever since 1834 with splendid results. But the new law at once made a great difference in the small-pox mortality of the German army, low as it already was—51 deaths in 30 years (1840-1869)—for it abolished the mortality altogether. There was no death by small-pox in the whole army for twenty years after 1874, with the exception of one in 1884, that of a reservist who had been twice unsuccessfully vaccinated, and there has been one death since. This proves that the protection which an individual acquires by vaccination and revaccination is greatly increased if he is surrounded by an equally protected community; and hence *it is the right and the duty of the State to insist on universal revaccination.* Then there will be no need for expensive isolation procedures, for there will be no more small-pox epidemics. Germany, Italy, Hungary, Roumania, and Japan—all have compulsory revaccination, and this country must follow.

ON THE ADMINISTRATION OF THE LAWS FOR THE PREVENTION OF EPIDEMIC SMALL-POX.

By Mrs. GARRETT ANDERSON, M.D.

It is the purpose of this article to explain in some detail how the legislative enactments intended to diminish small-pox in this country are put into effect. Acts of Parliament which have to be obeyed each time a child is born obviously need an elaborate and well-designed legislative machine. Success will depend almost as much upon the nice adjustment of the different parts of the organization for putting the law into practice, and upon the absence of friction between the different bodies concerned in the work, as it does upon the intrinsic merits of the law itself. It may be of use to see how the machine in this case has been constructed, and what connexion and what measure of interdependence exists between its several parts.

We have then to ascertain:

1. The department of Government charged with the duty of putting into effect the various laws intended to prevent epidemic small-pox.

2. The local bodies through which the Central Government Department works.

3. The powers entrusted to the local bodies, the agents they employ, and the measure of supervision exercised over them by the Central Government Department.

The only measures known at present for the prevention of small-pox epidemics are two: to render each person immune to the disease by efficient vaccination and revaccination, and to keep contagion away from such as are not protected by vaccination. It is obvious that the complete exclusion of contagion in crowded and mobile populations is impossible. The most that can be done in this direction is to remove cases of small-pox as they occur, and to reduce in this way the risk

of contagion to others in a limited though still valuable degree. The problem is, therefore, how to get every one in the community efficiently protected from small-pox by vaccination? Or, failing this, how to keep as large a part of the population as possible out of the range of the contagion of small-pox? The administration of the vaccination laws is much the more important part of the duty of the Government so far as regards small-pox. Isolation at its best would be powerless but for the aid of vaccination; even with its aid it is impossible to isolate early enough to prevent all contagion, and it is enormously costly. It is therefore the administration of the vaccination laws which is most worth study.

The Central Authority.

The first three Vaccination Acts—those of 1840, 1853, and 1861—were administered by the Poor-law Board. In 1871 this Board was superseded and replaced by the Local Government Board, which then became the Central Governing Department for Public Health and for the Poor Laws and for all other local government business. Poor-law guardians, county councils, town councils, urban and rural district councils, parish councils, all have to obtain the sanction of the Board before they can borrow money on the security of the rates or make by-laws.

Private Bills in Parliament promoted by municipal corporations and urban or district councils have to be submitted to the Board and exposed to its criticism both in and out of the House of Commons. The Board works by a large staff of inspectors of many kinds and by county and district auditors. The whole of the functions of the Board are vested in its President, but he is permitted to delegate his powers to the Permanent Secretary.

Local Authorities.

The year after the creation of the Local Government Board measures were taken to devolve local business upon local authorities. In 1872 England and Wales (excluding the metropolis) were divided into urban and rural sanitary districts, each of which was under the jurisdiction of its own sanitary authority. Urban districts included all boroughs and existing "Improvement Act districts." Rural districts were Poor-law unions or such parts of them as were not included in an urban district. In 1875 a comprehensive Act (38 and 39 Victoria, c. 55) was passed consolidating the law as it then existed and repealing nineteen Acts which had been passed since 1848. The Act of 1875 left the scheme of Public Health Law in the general form settled in 1872, and this form still remains. The Local Government Act, 1894 (56 and 57 Vict.) completely altered the constitution of the bodies entrusted with the administration of the laws affecting public health and the mode of their election. It gave additional powers and duties to the new bodies it created, but it did not take away the powers previously entrusted to their predecessors. In the place of the Boards of Health, Boards of Guardians, and Improvement Commissioners (elected by voters possessing a voting power varying with their property qualification), District Councils, elected by ballot by the ratepayers, were substituted. Boundaries were also readjusted, so that a district should not extent into two counties. From 1875 Boards of Guardians had been the rural sanitary authorities, but from 1894 the urban and rural district councils have been in charge of all matters affecting public health with the exception of vaccination, which remains in the hands of the guardians. The Rural District Council is a body corporate distinct from the guardians of the poor, though to a great extent the same persons are members of both bodies. The rural district councillors are elected by ballot, and a certain number of members of the Council are chosen to carry out the duties of guardians, instead of their being, as before, elected as guardians and becoming then *ex-officio* members of the sanitary authority. Since 1894 guardians have been free to elect their chairman and vice-chairman and to go beyond their own body for them. The guardians are therefore members of the rural district council (with in addition a chairman and vice-chairman), who have been selected to administer the relief of the poor, and who are not supposed to possess any special acquaintance with the requirements of sanitary science.

The sanitary authority in urban districts, other than boroughs, is the urban district council. Both urban and rural district councils are obliged to appoint a medical officer of health to carry on their sanitary work and to advise them generally upon all questions affecting public health; they are also obliged to have one or more inspectors of nuisances. The urban and rural district councils have to deal with all epidemics of infectious disease, including small-pox, to provide hospitals when necessary and to meet the cost of isolation.

The sanitary authority for county boroughs, and non-county boroughs, is the municipal corporation for each borough, which exercises all the powers of the Public Health Acts, and which has in some respects (for example, the power to promote Bills in Parliament), even more extensive authority than a county council.

Owing to the fact that vaccination is not controlled by the sanitary authority of each district, rural or urban, the medical officer of health has no official influence in regard to vaccination. He is the adviser of the district council but not of the guardians, with whom rests all responsibility as to carrying into effect the vaccination law. The guardians are bound to appoint a vaccination officer. It is his duty to notify to parents, at the proper time, that the law directs all children to be vaccinated, and to prosecute parents who for no sufficient reason disregard the law. The vaccination officer is paid partly by two small fees (3d. for each child on the register of births, 9d. for each child placed on the register as having been successfully vaccinated), but also by a salary from the guardians. In the not very rare case of the guardians having been elected to defy the law and to let vaccination lapse without the parent being punished, the vaccination officer's duty is to prosecute defaulters, even though this may be against the express instruction of his employers, the guardians, and it is also necessary for him to throw upon his employers all the costs arising out of his non-compliance with their wishes. It is the duty of the guardians to overlook the work of the vaccination officer and to keep him up to the mark. It may, however, be their wish to make his action as futile as possible, in which case their supervision does not promote his activity.

The guardians also select public vaccinators, subject to the approval of the Local Government Board, and they agree with them as to the price to be paid for the vaccinations they perform. The public vaccinator receives from the vaccination officer lists of all children who are then at the age to be vaccinated. He contracts with the guardians to vaccinate them at a certain price and under certain conditions. He is paid by the guardians. The public vaccinator, in the poorer parts of London at any rate, ought to be obliged to be ready to vaccinate at stated times. During the present epidemic people who wished to be revaccinated have frequently had great difficulty in getting the public vaccinator of their district to vaccinate them, owing to the want of a fixed time, and possibly also to a difficulty in getting enough lymph.

Both the vaccination officer and the public vaccinator are bound to obey the rules and regulations concerning vaccination laid down by the Local Government Board. Even in places where the guardians are anxious to promote vaccination there are practical disadvantages in the sanitary authority not having the control of vaccination. When a case of small-pox is discovered revaccination of all who have been exposed should be at once ordered. It is the medical officer of health who knows of the case in the first instance, but he has to wait till the guardians can be communicated with and can give the necessary orders to their officials.[1]

In the metropolis the London Government Act of 1899 created 29 municipal boroughs, each with mayor, aldermen, and council, which represent the former vestries. The borough council is in each case the sanitary authority, but vaccination is under the care of the guardians.

The second line of defence against epidemics of small-pox consists in removing sources of contagion as soon as the disease is recognized; it is known as the "method of isolation." It is impossible that it should be anything but a very imperfect method. Small-pox is not always a serious illness, especially in once-vaccinated people, and in every epidemic there are many cases that are not recognized early and probably not a few that are never recognized at all. Even very severe cases of confluent small-pox have during the present epidemic been recognized (and given in charge) from

omnibuses, the lifts of the Tube Railway, and similar places, where the risk of their having conveyed infection broadcast is very considerable. Such risks cannot by any amount of administrative zeal be avoided or removed. It is, however, no doubt very desirable, especially in densely crowded localities and houses, to remove each case of small-pox when recognized, and to surround it, at small-pox hospitals, with a cordon of people well protected by efficient vaccination. The duty of doing this has been assigned to the Metropolitan Asylums Board, a body which was created by the Metropolitan Poor Act of 1867. Its managers number 73. Of these, 18 are nominated by the Local Government Board, and the rest are chosen by the Boards of Guardians from among themselves. The Asylums Board is under the immediate control of the Local Government Board, and it is in no way responsible to the borough councils or vestries. It is defined as a "sanitary authority for the prevention of epidemic disease;" it would be more accurate to speak of "the limitation" rather than "the prevention" of such disease. It deals with infectious fevers, small-pox, and diphtheria, and also with defective children and imbeciles. It takes charge of the ambulance service of London. It has under its care twelve large fever hospitals, small-pox hospital ships on river and land, convalescent hospitals, land ambulance stations and wharves, hospitals for imbeciles, etc. Admission into any one of the hospitals under the Asylums Board is not equivalent to receiving parochial relief or alms, although the expenses incurred for the maintenance of such person are paid by the guardians of the Poor-law union from which he is received, and though the guardians are repaid out of the Metropolitan Common Poor Fund.[2]

The arrangements for removing small-pox and other infectious cases promptly, once they are recognized, are excellent. The failure in the case of small-pox to arrest an epidemic is not due to bad administration, but to the inherent impossibility of doing what is aimed at by means of isolation.

References.
[1] See Report of the Medical Officer of Health for Liverpool, 1902. [2] Public Health (London) Act, 1891, Sect. lxxx (2), (3).

Bibliography.
The Public Health (London) Act, 1891; Macmorran. The Law relating to Poor-law Medical Officers and Vaccination, 1901; Dr. Greenwood. The Law of Public Health; Glen and Jenkin, 1899, 2 vols. Encyclopaedia of the Laws of England, vol. x (Public Health). *Hazell's Annual*, 1900, 1902. *Whitaker's Almanack*, 1902. The New Order of the Local Government Board on Vaccination, October 21st, 1898. Judgment of Court of Appeal (Moore *v.* Keete), *Times*, March 6th, 1902.

VACCINATION PROBLEMS FOR PARLIAMENT.

By J. C. McVAIL, M.D.,
Medical Officer of Health for the Counties of Stirling and Dumbarton.

The Royal Commission on Vaccination recommended in 1896 that one of the principal changes which they suggested in the vaccination law—the passing of the "Conscience Clause"—should be made only experimentally for a period of about five years. That recommendation was accepted by Parliament as regards the whole of the Vaccination Act of 1898, which remains in force only until the end of next year—December 31st, 1903.

It is not conceivable that when the time comes the Act will simply be allowed to lapse without anything taking its place. It may be re-enacted without alteration, or fresh legislation may be introduced. The latter course is the proper one, and if there is to be fresh legislation it will have to be carried out by Parliament next year, so that between now and then Government—for it may be assumed that any new Act will emanate from Government—will have to consider and mature its proposals to be embodied in a new Bill.

It therefore now behoves the medical profession and the British Medical Association to consider without delay what action should be taken in the way of advising and influencing Government in this matter so important to the public welfare. The purpose of the present article is to direct attention to the principal questions requiring attention.

These overlap and are closely interlaced with each other, but may, perhaps, be most conveniently dealt with in the following order:

1. The local authority for the administration of the Vaccination Acts.
2. Efficiency of vaccination.
3. Public and private vaccination.
4. Calf lymph supply.
5. Revaccination.
6. The Conscience Clause.
7. Small-pox hospital accommodation.

1. *The Local Authority for Administration of the Vaccination Acts.*

There is a general consensus of opinion that Boards of Guardians are not the proper bodies for carrying out the Vaccination Acts. Their other functions have relation only to the Poor Law. Vaccination is esentially a public health measure, and its administration should be in the hands of that local authority which has charge of all other public health measures. This has always been obvious in theory and is becoming more and more obvious in practice. When small-pox breaks out in a locality the sanitary authority has the duty of removing cases to hospital and disinfecting premises and keeping contacts under observation, but to prevent small-pox it is most important that contacts should be immediately vaccinated and that all susceptible individuals in a threatened community should have every public facility for their vaccination or revaccination. At present in order to have this policy given effect to the sanitary authority requires to apply to the Poor-law authority. Clearly there must be some loss of time here, and clearly also the public body not charged with protection of the public health but responsible for the expense of public vaccination may take quite a different view of the urgency and necessity of the case from that taken by the other public body. Various examples have recently been published of the apparent inability of some local Poor-law Boards to grasp the elementary principles of sanitary administration. Being in the habit of dealing only with paupers, they seem to think that acceptance of the services of the public vaccinator is an act which takes undue advantage of the guardians and pauperizes the individual. Hence it is that complaints have been made at meetings of guardians that people able to pay privately have gone to the public vaccinator, and it has even been proposed to advertise the names of those so acting. But, as has been pointed out in the British Medical Journal, a man is no more pauperized by having his family vaccinated out of the public funds than he is by having them educated at a Board School.

One consideration bearing on the transfer of vaccinal administration to sanitary authorities remains to be noted. The composition of Boards of Guardians has not infrequently been injuriously affected by elections fought specifically on the question whether the Vaccination Acts should be carried out bona fide, or should, as far as possible, be evaded. A man who is elected simply because he is an antivaccinationist is not likely to be, with regard to the general work of the Board, the best man for the post. It would be deplorable if the general character of local sanitary authorities, whose functions are of so much public importance, came to be lowered through the transference to them of the administration of the Vaccination Acts.

That danger, however, is probably less now than it was before. The present interpretation of the law lays on vaccination officers the duty of taking legal proceedings independently of the views of the guardians on the enforcement of vaccination. Antivaccinationists have attempted to incite Boards of Guardians throughout the country to object to an official paid by them acting independently of them in this matter; but their efforts, which no doubt have had opposition to vaccination as part of their ultimate purpose, have not perhaps met with any great measure of success. At the same time Government certainly ought to endeavour to remove as far as possible everything open to criticism in their dealing with vaccination, and there seems no good reason why such work should not be put into the hands of public prosecutors who would not be either wholly or partly the paid servants of local authorities. Some such reform should be kept in view if the administration of the Vaccination Acts is to be handed over to the sanitary authorities. It need hardly be pointed out here that the whole scope and purpose of prosecutions is closely related to the Conscience Clause, which is considered later on in this article.

2. *Efficiency of Vaccination.*

In these days much is heard of the question of efficiency in all matters relating to the government of this country. Efficiency of vaccination, as depending on the thoroughness with which the operation is performed, has long been acknowledged to be of great importance, but the law has not yet done anything whatever towards its attainment. The Vaccination Acts contain no statement of either the area or the number of vesicles to be regarded as constituting efficient vaccination. For the purposes of the law one vesicle is as good as four, and a pinhead size as half a square inch or more. Any new Vaccination Act ought to provide that every certificate of successful vaccination shall state the number of vesicles attempted, the number produced, and their total area. Also, whatever be done regarding any extension of the field of public vaccination, as discussed in the next part of this article, no payment should be made from public funds in respect of any vaccination falling short of whatever standard might be specified in a new Act. It would, however, be of no use to insist that children primarily vaccinated in only one small place should be revaccinated at once. Experience shows that even one small genuine vaccine vesicle makes it practically impossible to successfully revaccinate immediately afterwards. But the facts about all persons thus insufficiently vaccinated should at least be put on record so that the fair fame of vaccination may no longer suffer from inefficiency in performance of the operation. At the same time it might be arranged, perhaps through an Order of the Local Government Board if the matter were regarded as too minute for direct legislation, that parents lodging certificates of such inefficient vaccination should have handed to them a printed memorandum pointing out the incompleteness of the protection received and the importance of its renewal so soon as susceptibility to vaccination had returned. This question of efficient vaccination is further dealt with under the next heading.

3. *Public and Private Vaccination.*

It has been frequently urged that every medical man who chooses to undertake the work should be regarded as a public vaccinator. There is much to be said for this view, though it is not to be denied that reasons can be advanced against it. Taking first what can be said in support of it, public vaccinators at present are all, or very nearly all, in private practice, and it is obvious that difficulty may easily arise between them and the regular medical attendants of families whom they are required to visit officially in order to offer vaccination. There are already more than sufficient opportunities for misunderstanding and friction between medical men, and there is no reason why these should be added to as the Vaccination Act of 1898 has done.

But that is only a minor reason for the change here considered. The public interest is very directly involved. In the first place, it is mere common sense to suppose that if every medical man could act as public vaccinator, the practice of vaccination and revaccination would be promoted throughout the country, and fewer persons would remain unprotected against small-pox. In the second place, it seems likely that on the whole the average efficiency of vaccination, as regards number and area of vesicles, would also be promoted.

The Vaccination Order of October 18th, 1898, includes the following instruction: "In all ordinary cases of primary vaccination the public vaccinator must aim at producing four separate good sized vesicles or groups of vesicles, not less than $\frac{1}{2}$ in. from one another. The total area of vesiculation resulting from the vaccination should not be less than half a square inch." Notwithstanding this instruction, the force of circumstances some time ago caused the Local Government Board to accept, in exceptional circumstances, a lower standard of efficiency of public vaccination, two marks not being absolutely excluded as a substitute for the four marks above specified. The reason is that in some communities medical men are to be found who are willing so far to yield to the pressure of ill-informed parents as to vaccinate in one place only. Indeed the columns of the BRITISH MEDICAL JOURNAL showed a while ago that at least one man possessing a medical diploma, and not professing to be an antivaccinationist, held that one mark is as protective as three or four. Where this is so, there is risk of some part of the less educated public resorting to such medical men instead of to public vaccinators who persist in making four marks. The Board, therefore, rather than have one-mark vaccination prevailing in a locality, did not see their way to entirely prohibit a public vaccinator who communicated with them on the subject from making only two marks instead of three or four. If every medical man in the country were to have a right to obtain payment as a public vaccinator for every vaccination done by him according to the required standard, men who make a practice of one-mark vaccination would have fewer people resorting to them, and the average of vaccinal protection throughout the country would probably be appreciably raised. Under the Conscience Clause there should be no need for any medical man yielding to the solicitations of nervous or foolish parents to make only one small mark on the baby's arm. Vaccination ought to be thoroughly done or not done at all, and any parent objecting to a sufficiency of area or number of marks should be sent away either to ask for a certificate of exemption or to return in a better frame of mind.

Two important objections have been made to any proposal that all medical men should, if they so desire, become public vaccinators. The first is that public vaccinators under present circumstances have special experience and skillfulness in their work, and may be expected to attain to a higher standard of insertion success than practitioners who vaccinate only their own private patients. It seems reasonable to believe that this must be the case. In the second place, public vaccination is at present under systematic inspection by the medical staff of the Local Government Board, and such inspection would be practically impossible if the number of public vaccinators were indefinitely multiplied. There is no doubt that this is so, and the fact has to be faced. All that could be substituted for the present excellent system would probably be a practice of surprise visits on the part of the Board's inspectors, or by medical officers of health not engaged in private practice. It would be the duty of a medical man, when sending in for payment his list of vaccinations, to certify quite definitely that at least once subsequently to the operation, but not earlier than eight days after it, he had inspected the arm, and that the Government standard of success had been attained in every case. Any false statement regarding any case on the list should subject the medical man to a severe penalty. It might even be for consideration whether a discovered repetition of false certificates should not be regarded as "infamous conduct in a professional respect," and fall to be dealt with accordingly by the General Medical Council. In this matter there would need to be no hesitation in acting with the utmost stringency. Such a system of surprise visits and severe penalties for false certification would not, I believe, be nearly so good as the present inspection by the Local Government Board's medical staff. The question therefore is, on which side does the balance of advantage lie? My own conclusion is that, as compared with the present system, the balance is in favour of conferring the status of public vaccinator on every medical man who desires the work.

It may be asked whether there is no other alternative to the existing system. There is another alternative, and it would consist in the appointment of a body of public vaccinators who should be entirely debarred from private practice. In this way the number of public vaccinators, instead of being indefinitely increased, would be strictly limited, and the supervision of them by the Local Government Board would be easily maintained. Being debarred from private practice, they could create no jealousies among the rest of the profession. If the local sanitary authorities were appointed to administer the Vaccination Acts, the offices of public vaccinator and medical officer of health might in some cases be combined, and if both vaccination and revaccination were made legally obligatory this department of work would be pretty regular in the amount of time required to attend to it.

I do not attempt to compare these two suggested schemes. Intimate departmental knowledge would be required to measure up in detail their relative value.

4. *Calf Lymph Supply.*

Relating to this same subject of public and private vac-

cination is the question of the supply of glycerinated calf lymph. The present state of things is certainly unsatisfactory. Either the production of vaccine lymph should be entirely in the hands of Government, or else private makers should be under Government supervision. In this way there would be greater security than at present as to the activity and purity of lymph, and in saying so I gladly acknowledge the general high quality, especially as to activity, of the material produced by firms throughout the country. If every medical man had the right to become a public vaccinator, and if the Local Government Board felt unable to accept the responsibility for keeping up a lymph supply sufficient for the requirements of the whole country, then the present system by which public vaccinators can always obtain Government lymph would no doubt have to be modified so that they could get some of their lymph elsewhere, but it would still be lymph sent out from places under Government inspection. The other course would be for Government to undertake the whole work itself. That might involve hardship to various individuals whose records of work are unimpeachable and whose supplies of lymph have been of the greatest value in times of need. Such facts ought to have full consideration given to them, and it occurs to me that the hardship might be minimized if present makers of lymph had the opportunity of being placed on the Government staff, which would obviously require increase under the circumstances indicated. That is a suggestion which may be valueless or impracticable; but, however the change may be brought about, the essential point is that no lymph should be used in this country unless produced by Government or under Government supervision. If every medical man were made a public vaccinator, means might require to be taken to prevent waste of lymph through practitioners asking for more than they really required. A small charge for every tube sent out should meet this difficulty; but that also is a detail.

5. *Revaccination.*

It is well known that when the Vaccination Act of 1898 was before Parliament, it was passed by the House of Lords only on the promise that the question of legislation for revaccination would be considered without delay by Government, with the view to its being dealt with in the next session of Parliament. Whatever consideration the question may have received, no legislation has yet been introduced. The contention of the Council of the British Medical Association has been that primary vaccination and revaccination should be placed on exactly the same footing as regards legal obligation towards their performance.

It need hardly be pointed out here that revaccination is a national requirement if the country is to be kept free from small-pox epidemics. If Parliament, in its wisdom, were to conclude that primary vaccination need not be in any degree compulsory, it should adopt the same conclusion as regards revaccination. If, on the other hand, Parliament determines that obligation towards primary vaccination shall remain as at present, or shall be made stronger, it should put obligation towards revaccination exactly on the same footing. Both are necessary for the public protection, and they should stand or fall together as matters of legislative concern. If the Conscience Clause is to remain on the statute book it should apply to both. The machinery for carrying out a law of revaccination is to be found in connexion with the Education Acts. Before a child leaves school, or say, at the age of 12 years, his parent or guardian should be called on to procure his vaccination, and if the parent or guardian neglects to do so, and at the same time neglects to take advantage of any Conscience Clause that may be in force, he should be subject to the same penalties as for neglect of primary vaccination. The same public facilities should be given for the performance of both operations, and what has been said regarding extension of the system of public vaccination applies alike to both.

It is very possible that many children whose primary vaccination had been omitted on account of so-called conscientious objection might be vaccinated at twelve years of age after the subject had once more to be definitely faced by the parent. The suggestion has been made that if the Conscience Clause is to remain relative to primary vaccination, the law should again come into force with regard to exempted children at the time of their entering school, so that all found unvaccinated at the age of about five years would be subjected once more to the provisions of the law, including once more the possibility of relief afforded by the Conscience Clause. Such a scheme might quite possibly turn out very useful, but on the whole, taken along with revaccination at twelve years of age, it seems somewhat complicated, and conceivably might have the effect of rather encouraging neglect of infantile vaccination, the parent keeping before himself the alternative of primary vaccination at the time of the child's beginning school life.

(6) *The Conscience Clause.*

Discussion of legislation for revaccination has necessarily introduced reference to the Conscience Clause, which has now to be further considered.

It cannot be too clearly pointed out or too often repeated that the purpose of the Royal Commission in recommending a Conscience Clause was not to lessen but to promote the practice of vaccination, by robbing the antivaccination agitation of perhaps its most powerful weapon. An outsider like the writer of this article has a difficulty in reaching any very decided judgment as to what has really been the result of the policy propounded by the Royal Commission and adopted by Parliament. Indeed, looking to the fact that other agencies besides the Conscience Clause have come into play —as the alteration of the obligatory vaccination age from 3 months to 6, the introduction of domiciliary vaccination, and the use of calf lymph instead of humanized lymph—it may be difficult even for those most directly interested in the question in England to dissociate and appraise the influence of the Conscience Clause. So far, however, as can be gathered from Parliamentary returns and medical journals, and the doings of antivaccinationists as reported in the press and in their own organ, the Conscience Clause seems to have had a really beneficial effect in helping the vaccination machine to work more smoothly, and consequently in promoting the practice of vaccination. The one outstanding fact which appears to me to outweigh in favour of its continuance all considerations to the contrary, is that it makes more easy the achievement of a national system of revaccination by legislative means. It is not sound reasoning to argue that if Parliament believes that universal primary vaccination and revaccination will prevent small-pox epidemics, therefore primary vaccination and revaccination must be made absolutely compulsory. The statesman may admit all that is claimed for vaccination, and yet may argue that a system of rigid compulsion might in this country be attended by political evils more serious than small-pox epidemics, and it does not belong to the medical profession as such to pronounce a final verdict as to the duty of Government and Parliament in circumstances like these. Looking plain facts in the face, however, a Revaccination Act apart from a Conscience Clause can hardly be expected, and might not work well if it were obtained. Still less can it be expected that Parliament would accept a Conscience Clause regarding revaccination without also continuing to apply it to primary vaccination. In the interests of the public welfare, therefore, it seems to me that the medical profession should rather accept a Conscience Clause as a basis for a revaccination law, than endeavour to have it repealed with regard to primary vaccination. That is an opinion which I would be inclined to hold even if it could be shown that the Conscience Clause had not so far promoted the practice of primary vaccination. Obviously the greater the neglect of primary vaccination the more need there is in school life for the protection against small-pox of those whose vaccination had been omitted, and who had been fortunate enough to escape attack by small-pox up to the age usually looked on as suitable for revaccination.

If we assume that the Conscience Clause is to be continued in the statute book, the question remains whether its provisions can in any way be improved. The original intention was that it should differentiate in a practical though somewhat rough and ready fashion between parents who might be regarded as having a definite and genuine objection to vaccination and other parents whose omission to protect their children would be due merely to indifference. The Conscience Clause was to operate by compelling every objector to take at least as much trouble to procure the exemption of his

child as to procure its vaccination. The trouble was to consist in the father requiring to attend a law court, and there make a declaration on oath that he seriously objected to vaccination. This was to involve some loss of time in every case, and might no doubt also involve some loss of money. In practice, however, the clause has not been administered with anything like uniformity throughout the country. In some places every facility has been given to diminish the time and trouble involved in registering conscientious objection. Mothers instead of fathers have been allowed to attend. Courts have been specially held at hours fixed to accommodate or encourage objecting parents, and the whole proceedings have been made as easy as possible, or reduced even to a farce by magistrates professing strong sympathy with antivaccinationists. On the other hand, a good many magistrates have erred in the opposite direction, and have refused to grant certificates to parents who have taken all the trouble that Parliament intended, to try to satisfy the magistrates of the reality of their objection to vaccination. Parents have been cross-questioned or bullied, and in the end certificates have sometimes been refused on the ground that the magistrates have not been "satisfied." For the proper working of the law a perfectly definite procedure should be enforced by Parliament, so that both of these faults would be avoided in future. There should be a clear statement of the hours when courts might be held, and of the forms requiring to be gone through, and of any fees exigible for certificates.

7. Small-Pox Hospital Accommodation.

Growing knowledge of the evil effects of small-pox hospitals on surrounding populations is not without a bearing on the question of legislation for revaccination. If vaccination and revaccination were universal there would be no need for small-pox hospitals. In the entire absence of vaccination and revaccination small-pox hospitals would be of practically no use, as epidemics would freely spread in spite of them. The present position being midway between these, small-pox hospitals do give an opportunity for treating cases of the disease whilst vaccination and revaccination are being carried out. But every epidemic of small-pox shows more and more clearly the dangers attached to such hospitals. Where they are in use on any large scale near any considerable population they are very likely, if not quite certain, to have the effect of spreading small-pox in the surrounding neighbourhood. The facts give very strong evidence that the spread is both aërial and by contact, and indeed it seems to defy every preventive measure.

If these conclusions are sound they raise some very serious questions. Where are sufficiently isolated sites for small-pox hospitals to be found? What right has a city community to determine that the residents in any particular locality within its own bounds, or in the country near it, shall be exposed to the risk? No doubt the city may say to the people of the selected locality, If you only take the trouble to get fully protected by vaccination and revaccination you will have no need to fear the propinquity of our hospital, even if it be full of small-pox patients. But, obviously, the people so addressed may retort to the city, If you all get vaccinated and revaccinated you will not require a small-pox hospital, but if you must have one then set it up among yourselves.

The financial question also is of some consequence. If in any community the majority of the people are willing to attend to their own vaccination and revaccination, and so to prevent their requiring incarceration in a small-pox hospital, why, they may ask, should they have to bear a share of the cost of building a hospital, and of nursing and maintaining therein persons who have refused or neglected to protect themselves?

From a practical point of view some heed must be given to the obvious fact that such hospitals are least harmful where the surrounding population is smallest in amount, and to evidence that small-pox hospitals are not so likely to prove centres of infection if the patients in them are very few. If vaccination and revaccination were obligatory in this country, there would be so little small pox that very little hospital accommodation would be required, and there would be very little opportunity for the hospitals doing any harm. But so long as vaccination and revaccination are neglected the hospital difficulty will remain, and it constitutes an additional reason for bringing legislation for revaccination into line with that for primary vaccination.

THE COMPLICATIONS OF VACCINATION.

By T. COLCOTT FOX, M.B., F.R.C.P.,

Physician for Diseases of the Skin to the Westminster Hospital, and to the Skin Department of the Paddington Green Children's Hospital; formerly Physician to the Victoria Hospital for Children and Medical Superintendent of the Fulham Small-Pox Hospital.

In a healthy subject the inoculation of pure vaccine lymph is followed by local manifestations of a very definite character, with periods of incubation, evolution, and decline, and by general symptoms, which we do not need to describe here. These symptoms, local and general, vary within certain limits, and, when they pursue a certain definite and recognized sequence the vaccinia is to be considered normal. Some variation will probably always occur, in so far as it depends on the state of the tissues of the subject, and on modifications in the activity and amount of the vaccine lymph inoculated; but a greater uniformity will be reached as the preparation of the vaccine lymph becomes perfected, and as the best method of vaccination, including after-treatment of the pocks, becomes more generally adopted. The reaction may vary considerably in intensity, and a successful revaccination in the adult is generally accompanied by more intense inflammatory phenomena than a primary inoculation in a child (Brouardel). The reaction to calf lymph is also apt to be somewhat more severe, with more local swelling, oedema of the arm, adenitis, and radiating pains.

At present it is not rare to meet with variations from the normal which must be set down as abnormal, and they chiefly depend on the condition and susceptibilities of the subject, on the quantity and quality of the virus and its contamination with undesirable organisms, on the degree of disinfection of the skin, on the method of inoculation, and on the subsequent treatment of the pocks and contamination from without.

A *Lancet* Special Commission which investigated all the glycerinated calf lymphs on the market and the Local Government Board lymph, had the satisfaction of reporting[1] "that although the lymphs then on the market differed very greatly as regards their bacterial purity, they were, taking them as a whole, eminently satisfactory." And in a further report[2] the Commission confirmed this conclusion, but added that "there is still room for improvement, since there is yet much diversity in respect to the degree to which extraneous bacteria are present." "The results," it is added, "of the investigation carried on by the Commission appear to indicate still more clearly that the efficacy of the vaccine is not necessarily impaired in those cases in which the glycerinization has been carried to such a point that practically all the bacteria have been got rid of."

The vagaries, anomalies, and complications of vaccination have been fully dealt with by Dr. Theodore Acland in an elaborate and scholarly essay in Professor Clifford Allbutt's *System of Medicine*, with which every vaccinator should be cognisant. His observations refer no doubt chiefly to the old system of vaccination, but are also applicable to the modern calf-lymph inoculation. The latter, whilst exciting some increased reactionary effects, eliminates almost entirely the possibility of the inoculation of such diseases, amongst others, as syphilis, leprosy, and tuberculosis.

Many of the *variations in the development of the vaccine pocks* are of comparatively little importance, and need only a brief reference. For example, the incubation period varies. The pocks may develop unequally, or they may be somewhat accelerated or retarded for a fortnight or even, it is said, up to thirty days. In this connexion we may note the assumption of activity under the influence of a revaccination at points where the inoculation performed a week or more previously appeared to come to nothing. The recrudescence, or relapse, or revivifying of a pock after some weeks is said by some to be not infrequent. The cause is not clear, and the occurrence may be of little moment, but has been found

associated with grave events. The contents of the pocks may remain watery, or form pus too rapidly, or become haemorrhagic; and when the latter is not due to injury these symptoms may mean contamination. Then it is not uncommon to find the pocks arising at the original sites of inoculation surrounded by supernumerary or extra vesicles, and to this we shall refer again.

In revaccination the pocks may be altered and not fully developed according to the degree of immunity possessed by the subject. The lesions may form only a pink papule perhaps more or less vesiculated, and these were denominated *vaccinoids* by Hervieux.

In America a peculiar complication known as the "raspberry sore" has been written about. P. A. Morrow, writing on the Incidental Effects of Vaccination,[3] said it had been recognized from the introduction and general use of animal vaccination in America, but doubted it being a specific product of the bovine lymph, as it displayed certain points of resemblance with the red tubercle described by Bousquet occurring after the use of human lymph. It has been noted exceptionally on the calf, and is probably not infrequent in this country. The writer of the present article was alarmed by its appearance on his own arm. In the special number of the *Philadelphia Medical Journal*, November 23rd, 1901, on small-pox, the "raspberry excrescence" is mentioned by Welch and Schamberg, who say it usually appears from three to seven days after vaccination, beginning as a red elevation at the site of inoculation, quite similar to the papule of true vaccinia, but instead of advancing to the vesicular stage it remains hard, dense, bright red in colour and nodular in form, looking not unlike a small naevus. They add that it is very persistent, remaining usually weeks or months, is not followed by a scar, and does not confer immunity. F. S. Fielder says it only protects temporarily, and is evidence of a poor lymph. Morrow, however, stated that it disappeared spontaneously in four to eight weeks. In my own case the excrescence was rapidly dissipated by a mercury and carbolic acid plaster applied by Radcliffe Crocker's advice. F. G. Gardner described in these columns a case in which two of the inoculations out of four became the seat of a granuloma. Sobel[4] draws a distinction between "exuberant granulations" and the dry exuberant raspberry growth of granulation tissue.

With regard to an *excessive degree of local inflammatory reaction*, we have mentioned that some excess may occur after the use of bovine lymph and in revaccinations. Idiosyncrasy also often plays a great part, and a too free use of a vaccinated arm is sometimes to blame. Impure lymph, however, and secondary infections with pyogenic microbes, due to unclean instruments, or at a later period to contact with contaminated coverings or hands, are mostly at fault. In association with these conditions, the inflammatory areolae may be very pronounced or extensive (so-called pseudo erysipelas); oedema of the arm may be pronounced, and more or less tenderness and swelling of the related glands may be set up. Glandular suppuration is rare. The confluence of pocks, too closely placed or supernumerary, or the severity of the local inflammation may lead to loss of tissue and ulceration over a comparatively large area or limited to each inoculation. If simple, this loss of tissue may soon heal, but if unhealthy the ulceration may extend deeply, be protracted, and even take on phagedenic characters. Such untoward results may affect one out of a batch of healthy operations, and is then probably due to secondary influences; or, as in the epidemic investigated by Leloir, the chancriform ulcers may affect many of the batch, and be due to bad lymph.

Lastly, we have *variations in the healing and formation of scars*. Vaccination wounds should be well and firmly healed before the end of the third week. Such preventable causes as injuries dirty shields and dressings, may delay healing for weeks or months. Sometimes the state of the child is at fault. Hypertrophied scars may occur as after other wounds, but tend to flatten down in time. True keloid is rare and more troublesome. I have seen one or two cases in which there was a tendency to keloid throughout life after the formation of any scar, showing some constitutional tendency.

Amongst the *complications of vaccination*, eruptions on the skin attract the particular attention of the public, as in their view evidence of blood poisoning in the vicious sense. The rare spontaneous generalized vaccinia eruption and the auto-inoculated vaccine pocks are probably the only ones peculiar to vaccination. As already stated, local supernumerary vesicles are not infrequent, and are of interest as similar to the occurrence in inoculated small-pox; but in the later a generalized eruption followed about the ninth to the fourteenth day. Very also rarely vaccination is complicated by a exanthematic generalized outburst of true pocks. Its date of appearance varies considerably, but is generally from one or two days before to one or two days after the maturity of the original pocks. A similar generalized eruption can arise from the introduction of the virus through the digestive, circulatory, or respiratory systems, as, for example, by a child sucking its vaccination pocks. The elements continue to evolve for seven, ten, or fifteen days. M. L. Heidingsfeld[5] quotes Chauveau to the effect that generalized vaccinia occurred only 6 or 8 times in 500,000 to 600,000 vaccinations, and Bondersen reported only 3 cases out of 170,596 vaccinations in Denmark. This exanthematic generalized vaccinia must be carefully distinguished from the dissemination of supernumerary vesicles due to the auto-inoculation of the contents of the primary and subsequently other pocks in a hundred and one ways. Such a multiplication may be scanty and localized, or copious over a particular region, especially eczematous surfaces, or generalized. In this connexion Acland says that observations go "to show that under ordinary circumstances the receptivity of an individual to successive vaccinations in series gradually diminishes during the second week, and usually becomes extinct before the fourth." Cory found immunity was attained after the ninth day. In diagnosing these eruptions from herpes iris, impetigo contagiosa, and other vesicular, pustular, and bullous outbursts, let us remember that the true vaccine pocks are capable of inoculation in the animal or child.

Of the eruptions not peculiar to vaccination there is a group embracing all types, from the erythematous to bullous and and haemorrhagic; and they may accompany typical local pocks. Sobel[6] found about 2 per cent. of 4,160 cases had a generalized eruption. These eruptions are probably for the most part due to some chemical irritant, for one may meet with them on occasion in the course of almost any infection, for example, after the injection of antitoxins, serums, and physiological saline solutions (subcutaneous or intravenous) following enemata, and the administration of drugs by inunction, subcutaneously, or by the mouth These coincident, or incidental, or indirect vaccinal eruptions fall into two categories. They may undoubtedly be directly due to the absorption of the pure vaccine virus, and are then benign, temporary, and of little importance. On the other hand, they may be due to the inoculation of impure lymph, or to the subsequent contamination of the pocks or sites of vaccination. It is obvious that the latter group may be of considerable significance. These eruptions occur from the ninth to the fourteenth days, most frequently on the tenth to twelfth, sometimes as early as the fifth, sometimes as late as the fifth week. In accepting the vaccinal origin of the late eruptions one must bear particularly in mind the adage *post hoc propter hoc*. The pathogeny of these eruptions is not well understood. They only occur in a small proportion of cases of any given infection or intoxication, and idiosyncrasy seems to play a considerable rôle. The eruption may consist of fugitive rose blotches, or it may be of the congestive rash type such as scarlatiniform, or like rötheln or morbilliform, or of a larger macular type, often called roseola, or again of a still bolder and more pronounced inflammatory type such as we commonly include under the symptom-complex erythema multiforme. Even the extreme phases such as the so-called herpes iris and bullous erythemata may be met with. In diagnosis it should be borne in mind that a subject may be incubating one of the acute specific fevers at the time of vaccination.

Various phases of urticaria are met with in the adult, but in the child its place is most commonly taken by the closely allied lichen urticatus of Bateman or strophulus, as we prefer to call it. Our readers may be referred to Allbutt's *System of Medicine* for a description of this frequent and polymorphic eruption.

In addition to the trifling miliaria and sudamina, some papular and vesicular eruptions are occasionally met with, as after the ingestion of drugs, somewhat difficult to classify

but usually of little significance. In an epidemic of septicaemia investigated by Brouardel, the local eruption was replaced by a sero-purulent dermatitis, and followed by a generalized impetiginous eruption. Temporary pemphigoid eruptions have long been noted as a rare complication, but, since the use of calf lymph, particular attention has been drawn to their occurrence, which is of a somewhat grave character, from its severity and tendency to chronicity. In the *Journal of Cutaneous and Genito-Urinary Diseases*, September, 1901, J. T. Bowen reports six cases of bullous dermatitis, and refers to other recorded cases. In three of the cases the eruption appeared within two weeks after vaccination, in one within a week, in two after a month. In none were there signs of sepsis, and in none signs of intense local reaction. According to Bowen, "the chief features that these cases present in common, and that lead to the conviction that they have a common etiology, are their occurrence in children after vaccination, their course varying from several months to several years, or perhaps longer; their uniform vesicular and bullous characters, with only occasional evidences of multiformity; the usually almost complete exemption of the trunk; the characteristic grouping about the mouth, nose, ears, wrists, ankles, and feet; and the very slight prominence of itching and other subjective symptoms beyond those common to any interference with the integrity of the skin." These cases are of course quite distinct from those of acute bullous erythema multiforme. Lately Sequeira (May, 1902) showed to the Dermatological Society of London a man who was revaccinated in three places. The vaccination ran a normal course, and completely healed by the fourteenth day. Three weeks later one spot recrudesced and ran its course again, and three weeks later again a very severe pemphigus set in. Galloway recited a somewhat similar case. The pathogeny of many cases of pemphigus and dermatitis herpetiformis is not clear, but, as Bowen says, possibly a toxin is in action on certain predisposed persons, as in the "herpes gestationis" of parturition.

Purpura is of very rare occurrence. It is a symptom with a manifold pathogeny. Acland thinks it is probably analogous to the well-known cases of haemorrhagic variola or scarlet fever, but probably it signifies a secondary infection.

A word may be said about the very rare occurrence of disseminated gangrenous lesions, the so-called vaccinia gangrenosa. This is to be carefully distinguished from the local gangrene or necrosis which sometimes occurs at the points of inoculation. Many cases of multiple gangrenous eruptions have been recorded in children and adults, and organisms isolated. Vaccinia gangrenosa may possibly be the result of a specific eruption due to an infection with a special organism, but we recognize that the varicella eruption under certain conditions in tuberculous or cacchetic children may become gangrenous, and similarly we know a papulo-pustular eruption in infants which rapidly ulcerates, of all degrees of gravity, the so-called ecthyma térébrante infantile. It is possible that various eruptions may assume this ulcerating or gangrenous form when engrafted on suitable soils or complicated with particular organisms.

It is possible that impure lymph containing organisms, such as staphylococci or streptococci, may contaminate the vaccine lesions from the start, and produce grave systemic poisoning, which may be evidenced by generalized rashes, or, perhaps very rarely, vesico-pustular eruptions. Such results, however, are generally due to improper methods of vaccination, or, still more often, to secondary contamination of the points of inoculation from the subsequent treatment of the wounds. It used to be a very frequent occurrence, and one which had much to do with the prejudice against vaccination, to see impetigo and ecthyma from staphylococcus or streptococcus infection of the wounds inoculated about various parts of the body by scratching, infected dressings and clothing, and so on. If the virus be virulent, large, flat, spreading blisters may be rapidly produced to form a more or less general eruption, and grave results might follow in infants. Similarly furuncles or abscesses may result. The spread of the streptococcus pyogenes in the deeper structures causes erysipelas, which has become far less common than formerly. It is necessary to distinguish the inflammatory blush, which is often excessive, arising around the inoculated regions from true erysipelas. This blush is probably due to the irritation of the developing pustule, but possibly may be due to extraneous pathogenetic bacteria. In considering the origin of erysipelas, the date of its appearance should be carefully observed. Acland writes as follows: "It seems probable, if one only of a number of children vaccinated from the same source develops erysipelas later than the fourth or fifth day, that the erysipelas is due to some extraneous cause, and is not invaccinated. On the other hand, if a number of children vaccinated from a common source develop before the fourth day, only one or two of the whole batch escaping, the probability is very great that the erysipelas is directly due to the lymph or to some factor at the time of vaccination." Most of the recorded cases have evidently been due to secondary contamination of ruptured pocks or torn crusts.

Tetanus is a complication of very rare occurrence in vaccination, at any rate in this country, though probably it may be more frequent in the tropics. The bacillus comes from dirt or earth, and may follow as an accidental infection of any wound. The recent occurrence in America of a group of cases of post-vaccinal tetanus has recently (May 3rd, 1902) been discussed in this Journal. The infection in this group of cases was probably secondary.

Psoriasis, eczema, and strophulus are eruptions which may occur in close association with vaccination. Psoriasis is a recurrent eruption which is uncommon before the third year of life, and very rare in the first year. We do not know its cause. It may possibly be a local parasitic disease, but is probably what may be called a constitutional eruption. Many cases have now been observed in which it has arisen for the first time in the course of the vaccination process, and then some of the elements may actually be determined to the sites of vaccination. In two cases noted by Wolters there was a family history of the eruption. The pathogeny of the so called eczema of childhood is also undetermined. It is also possibly a local parasitic disease, and is of great frequency in infants, even before they are vaccinated. A study of my cases has not convinced me that there is any direct relation between "eczema" and vaccination. Strophulus I have already referred to. It is one of the commonest eruptions of childhood, and in its production the vasomotor nervous system probably plays a conspicuous part. Undoubtedly it is very frequently excited by vaccination, as by the acute specific infections and other general states.

Finally, we come to a group of diseases, syphilis, tubercle, leprosy, which may possibly be inoculated at the time of vaccination or by subsequent contamination. Acland points out that "the facts brought before the Royal Commission (1889-1896) prove that, in England at any rate, the event is one of great rarity." Certainly I have never met with a case, nor have I heard of any of my contemporaries in London having done so. Neither have I seen in over twenty years' work in children's hospitals any suspicious cases occurring in vaccinated syphilitic children, beyond the local chancriform ulcer of the arm. The introduction of vaccination with bovine lymph renders the invaccination of syphilis impossible, unless a syphilitic vaccinator himself contaminates the lymph or wound. As however a vaccinator should be armed with the knowledge to make a clear diagnosis, I will quote Acland's description of the sequence of events where syphilis has been invaccinated. All the points of insertion are not necessarily infected. "If the person vaccinated be susceptible to vaccination the pocks may not at first show any departure from the normal course, but in some cases the pocks abort, and the pathological process seems to be at an end until the syphilitic virus asserts itself. If the pocks be irritated, or the condition of the tissues be such as to favour suppuration, the vaccinal sore may become inflamed, suppuration may occur, and the ulcers may for a time scab over and then break down again; but in any circumstances, whether the vaccination pursue a normal or an abnormal course, a true syphilitic chancre with indurated base eventually forms at the point of inoculation." The chancre does not develop before the end of the third week, usually the end of the fourth or even fifth week. There is then the second incubation and indolent swelling of the glands, and generalization between the fiftieth and seventieth day (sixth and tenth week, Hutchinson), and the specific eruptions, and other manifestations have their well-known characters and sequence.

The possibility of the inoculation of tuberculosis is really

a much more important problem, but here the danger seems now infinitesimal when we consider that tuberculosis is rare in calves, and that lymph from a calf should not be used until the animal has been killed and proved to be free from tuberculosis. It will therefore be hardly necessary here to enter into a discussion on the possibilities of tubercle invaccination under the former order of things. There is little advantage also in referring to cases of lupus vulgaris involving vaccination scars where the histories are too remote or vague to be of value. I have, however, observed three infants in whom one or more of the vaccination scars became the seat of a tuberculous patch on the healing, or very soon after the healing, of the wound. One child was inoculated with calf lymph by a very experienced vaccinator and other children vaccinated in the same batch experienced no ill-effects. Graham Little has recently published these cases in his paper on Vaccinal Lupus.[7] Though they certainly raise unpleasant suspicions, I do not think any conclusion of scientific value can be drawn from them. The vaccination sores may have been inoculated secondarily, or a previous tuberculous centre may have existed and an embolus found its way to the scar.

With regard to leprosy, it is not proved, however probable it is, that the disease can be communicated directly by inoculation, and further by vaccination. The cases recorded in which the invaccination of leprosy has been suspected will not stand investigation.

The recital of this list of possible complications, which may arise under every conceivable condition, is apt to excite a very false impression of the dangers attending vaccination, and may be taken undue advantage of to prejudice the public. Allowing for some variation in the local and systemic effects owing to the varying activity of the virus and the susceptibility of the subject, there are very few complications that it is not in our power to avert by using a pure lymph, conducting the operation in a proper manner, and preventing any secondary contamination. In terminating this sketch I will quote the following conclusion of the *Lancet* Commission, which is of great practical importance: "We are strongly of opinion that many of the bad results obtained in vaccination are due to the presence of one or other of the following conditions: Imperfect sterilization of the skin and want of protection against the invasion of the weakened and abraded tissues by extraneous organisms. We have found that, given a good lymph, the application of a plentiful supply of soap and water, a razor to take off hairs and surface epithelium, ether to remove fatty and sebaceous matter, alcohol to wash away the ether, superficial vaccination (by sterilized instruments), and protection of the vaccinated surface throughout the whole course of the local manifestation of vaccinia, most excellent results may be obtained. The best means of protecting the local lesion is the application of several folds of sterile lint containing no chemical disinfectant; that is held in position by strips of adhesive plaster; a layer of boric lint may then be placed outside this dressing, and the whole may be changed as soon as the slightest evidence of moistening by serum appears in the boric lint." By the observance of these conditions the vagaries and mishaps of vaccination will be reduced to a minimum, and the perfect result characterized by "typical vesicles, slow of development, with little inflammatory areolae, and late in coming to maturity," will be attained.

References.

[1] *Lancet*, April 28th, 1900. [2] Ibid., June 7th, 1902. [3] *Journ. Cut. and Ven. Dis.*, vol. i, 1883. [4] *Medical News*, August 11th, 1900. [5] *Journ. Cut. and Gen. Urin. Dis.*, February, 1902. [6] Loc. cit. [7] *Brit. Journ. Derm.*, March, 1901.

GLYCERINATED CALF LYMPH,

By F. R. BLAXALL, M.D., D.P.H.,

Bacteriologist to the Vaccine Department of the Local Government Board and Lecturer on Bacteriology at Westminster Hospital Medical School.

[From the Government Lymph Laboratories, Chelsea Bridge, S.W.]

The methods employed in the preparation of glycerinated calf lymph at the Vaccine Establishment of the Local Government Board are those which our experience has shown are most conducive to the production of well developed active vaccine vesicles, and to the subsequent manipulation of these in such a way that the vaccine is never exposed and never comes in contact with other than sterile instruments. Further, repeated bacteriological test is employed to ascertain that such lymph before issue is entirely free from harmful micro-organisms.

The Selection and Preparation of the Calf.

The calf is the most important factor in the production of good vaccine, and calves vary so enormously amongst themselves in their response to vaccination that no care and no knowledge can be too great to assist in the selection of those most suitable. After a journey calves need a rest before vaccination. They should be housed in clean, airy, well-ventilated stables, kept as far as possible at an equable temperature; they need to be fed in the manner and with the materials most appropriate to their age and condition; indeed, in this respect it is hardly too much to say that each calf requires individual treatment. The most suitable calves are those from three to six months old, with smooth supple skins, clear eyes, and, generally, in the pink of condition. They should be kept under observation for a week, the weight ascertained, and the daily temperature. Everything being satisfactory the calf is ready to be prepared for vaccination.

For this purpose it is placed on a tilting table, constructed in such a way that every part of it can be kept thoroughly clean, that no moisture (urine, washings, etc.) can accumulate on the table, and with fastenings so arranged that no cramping of limbs can occur. The lower part of the abdomen of the calf is then shaved as far forward as the umbilicus and backwards as far as the thighs. This is an operation requiring care and skill, it being important that the skin should not be cut or abraded. The size and position of the area to be shaved for vaccinating purposes must, however, be actually determined by the condition of the particular calf, by the season of the year, and so forth. Sometimes calves respond much better to vaccination at one part of their skins that at another. The shaved area is well washed, rinsed with tap water, and finally cleansed with sterilized water. The moisture from such washings is removed from the shaved area and from the adjacent hair by means of sterilized gauze sponges.

The Vaccination of the Calf.

The calf is then vaccinated with glycerinated calf lymph, introduced into the skin in parallel linear incisions by a sharp scalpel. The incisions are of such a depth that they only pass through the epidermis and lay open the rete Malpighii. Care should be taken not to draw blood, as this is very apt to prevent the formation of perfect vesicles.

The vaccination of the calf requires practice and constant care, the incisions should all be of uniform depth, and there should be no gaps. As the incisions are made, more lymph is run in along the lines by the aid of a sterilized ivory spatula. The lymph must be distributed evenly along the line. The inoculation of the incisions must be effected as soon as they are made, otherwise the lips of the wound are apt to swell and close the opening.

After vaccination the calf is removed to a clean stall and kept in such a way as to prevent any injury to the vaccinated surface. The temperature of the stable should not fall below 60° F.

Collection of the Vaccine Material.

When the vesicles on the calf have reached maturity—generally in this country 120 hours after inoculation, but sometimes before, even as early as 96 hours—the animal is again placed on the operating table and the vaccinated surface is thoroughly washed with soap and warm water gently rubbed over it by the clean hands of the operator. It is well washed with tap water, and finally cleansed with sterilized water and the moisture removed with sterilized gauze sponges.

At this stage the site of each incision should present a line of even and continuous vesiculation; but this is by no means always the case. Sometimes the vesicles have been retarded in their development and show a tendency to dry up and form crusts, or they may be over-developed and advanced or may present an irregular and ragged appearanee. It is from the careful consideration and from the knowledge of the value of all these points that the quality of the lymph has to be determined.

The skin of the calf is put firmly on the stretch and the vesicles and their contents collected with a sterilized Volkmann's spoon, each line being treated in turn and scraped. The pulp thus obtained is received into a sterilized stoppered bottle. The abraded surface of the calf is then gently washed with warm water and the animal is removed from the table and weighed. The calves nearly always show a considerable gain in weight during their stay at the station and during the vaccination process. Each calf is transferred to the slaughter-house and is there slaughtered. A complete examination of the carcass and the viscera with a view to the recognition of tuberculosis is made on behalf of the Board by a veterinary surgeon appointed for that purpose. A report of the examination is received at the laboratories next morning. No lymph is used unless the animal in question is certified to have been healthy. The number of tuberculous calves at this age is very small.

Glycerination of the Vaccine Material.

The bottle containing the lymph pulp from each calf is taken to the laboratories, where the exact weight is ascertained. The pulp is next passed through a triturating machine consisting of a continuous screw, with diminishing worm revolving in a closely-fitting cylinder. The machines used are a modified form of the one invented by Dr. Chalybäus of Dresden. All the parts of the machine which come in contact with the lymph pulp are previously sterilized by prolonged steaming. The machines are driven by electric motors. Passage through the machine reduces the pulp to very fine particles, and this ground-up pulp is then gradually mixed with the proportionate quantity of glycerine and water. Usually in the laboratories the pulp is mixed with four times its weight of sterilized mixture of 50 per cent. pure glycerine in distilled water, but the amount of dilution should depend, whether more or less, upon the previously-adjudged quality of the lymph. The pulp mixed with some of the glycerine water is again passed through the machine, the remainder of the fluid being added during the passage. The resulting mixture is then once more passed through the machine, thus producing a fine and intimate emulsion.

At this stage a bacteriological examination is made of the glycerinated lymph; a loopful of the emulsion is withdrawn by a sterilized platinnm needle, and agar-agar plates are established in order to estimate both the number and the quality of the organisms present in the lymph.

Storage of Emulsion.

The emulsion is next carefully poured into small sterilized test tubes capable of holding 4 to 10 c.cm. Each tube is filled as completely as possible, so that very little air is in contact with the emulsion. The tube is plugged with a sterilized cork, is sealed with melted paraffin rendered aseptic with carbolic acid, and is then placed in a cool cupboard or ice chest.

Bacteriological Examination of the Glycerinated Lymph.

As already stated at glycerination a bacteriological examination is made by means of agar-agar plates. After suitable incubation for seven days—twenty-four hours at blood heat and six days at room temperature—the colonies that have developed on these plates are counted and examined. Week by week this process is repeated, and invariably the number of colonies diminishes with the age of the emulsion. The elimination of the extraneous organisms is due to glycerine acting in conjunction with heat. The higher the temperature at which the glycerinated lymph is kept the more rapid the elimination; the lower, the reverse. The precise temperature at which glycerinated lymph should be kept for the elimination of the extraneous organisms and for the preservation of its specific activity is a matter requiring most careful consideration, presupposing as it does a very accurate knowledge of the quality of the lymph and the exact stage of maturation of the vesicles. In this way each lymph must be considered on its own merits.

The number of extraneous organisms contained in different lymphs varies enormously. Speaking generally, the better the quality of the lymph the fewer the number of organisms, and vice versa. During the process of glycerination the greatest destruction of the extraneous organisms takes place within the first week. Thus, if at glycerination a lymph shows 25,000 organisms per loopful, at the end of the first week this number will probably be reduced to 2,000 or 3,000, at the end of the second week to 500 or 600, third week to 40 or 50, fourth week only 2 or 3 will be left or none. On the other hand, lymphs which show but few organisms at glycerination may be quite germ-free by the end of the second week.

The number of varieties of organisms found in our laboratories in glycerinated calf lymph is very small, and is practically limited to two—staphylococcus aureus and staphylococcus albus, aureus as a rule predominating. Numerous experiments with these staphylococci freshly isolated from calf lymph and injected into rabbits and guinea-pigs have shown that they have no pathogenic action for these rodents.

Also in glycerinated lymph are found bacillus mesentericus and its allies. These are more resistant, and if present frequently escape destruction. Proteus vulgaris sometimes occurs in lymphs, and is best discovered by means of fluid cultures, as shown by my colleague Mr. H. S. Fremlin. It is easily eliminated. Mr. Fremlin has also shown that no strictly anaërobic organisms occur in glycerinated calf lymph.

In this connexion it is interesting to note that the *Lancet* Commissioners, in their reports on glycerinated calf lymph, classify the extraneous organisms found in the various samples of lymph examined by them as aërobic and anaërobic. It appears that the latter term is assigned by the Commissioners to any organism capable of growth in the depth of glucose agar or glucose formate agar. Growth of the organisms in these media, however, does not necessarily entitle them to be called anaërobic unless it is shown that they will not grow equally well aërobically. Rather they should have been called facultative. In these laboratories exhaustive experiment has shown that, with the exception of bacillus subtilis, all the extraneous organisms found in lymph are facultative—that is, are capable of growing equally well under aërobic and under strict anaërobic conditions. In these circumstances, therefore, the Commissioners' classification cannot be accepted, and they have, in enumerating the organisms growing on surface agar and in glucose or glucose formate agar from the samples of lymph supplied to them, for the most part, undoubtedly counted the same kinds of organisms twice, and in any case have failed to show that they were not the same.

The streptococcus has never been found in the lymphs in these laboratories, nor have tubercle bacilli been discovered in lymphs which have been derived from tuberculous calves, and such lymphs when injected into guinea-pigs have invariably failed to produce any tuberculous lesions.

Use of the Lymph at the Animal Vaccine Establishment Prior to Distribution.

When the stage is reached at which the lymph is known to be free of any harmful organisms, and is practicaliy germ free, samples of the lymph are drawn up into capillary tubes, and dispatched to the Animal Vaccine Establishment for the vaccination of children. The results of these vaccinations are recorded a week later, and from the number and size of the vesicles obtained an estimate of the potency of the lymph at this time is made.

Transference of the Glycerinated Lymph to Capillary Tubes for Distribution.

When the lymph of a given calf has been shown to be satisfactory, it is transferred to sterilized capillary tubes by means of special tube-filling machines worked by water power. The tubes contain sufficient lymph for the vaccination of one case, and are sealed in a small gas flame, every care being taken in the process to prevent overheating of the lymph. These tubes are then stored in boxes in an ice chest in such numbers, that any quantity can be at once be dispatched to the National Vaccine Establishment at Whitehall for issue to public vaccinators. During seasons, however, when small-pox is epidemic and the demand for lymph very great, all the lymph is not issued in capillary tubes in this way, but it has been found convenient and useful to send lymph out in small sterilized tubes, each containing sufficient lymph for ten or twenty-five vaccinations. These have a special advantage where several cases can be vaccinated or revaccinated in the same place.

Instructions with the Tubes.

Instructions are sent to each public vaccinator with the tubes, first, to ask only for such quantity of lymph as is immediately required; secondly, not to use lymph more than a week after it has been received, but to return it; thirdly, to keep the lymph in a cool and dark place. These instructions are designed to promote a proper care in the employment of lymph and to prevent waste.

Duration of the Activity of Glycerinated Lymph.

This depends primarily upon the quality of the lymph when collected. A first-class lymph, glycerinated and kept under suitable conditions, may retain its full activity for a year or longer, an average lymph, however, cannot be depended upon to remain fully potent longer than two months, and one of inferior quality still less. It is in this respect of range of activity that the determination of the quality of the lymph at the outset is a matter of such importance. It must be understood that the human subject is, as far as is known, the most susceptible animal to vaccinia, and that the transference of vaccine vesicles from the calf to the human subject, with or without glycerination, even if the calf vesicles are not of the first quality, will produce a human vaccinal manifestation typical in every respect, and therefore in all probability possessing full immunizing powers, provided that the calf lymph be used within its period of full activity. In calf lymphs of poor quality the duration of potency may be very short, in some cases hardly compatible with the complete effects of glycerination. Such lymphs need to be recognized at the outset and discarded.

Issue and Results.

Some of the more recent figures of the issue and results of glycerinated calf lymph prepared in these laboratories may be of interest, especially in relation to the current outbreak of small-pox. During the year ending March 31st, 1902, sufficient lymph has been issued for 974,595 vaccinations and revaccinations. The maximum amount dispatched in one week was 80,000, in the third week of January, and during the month of January 220 000 tubes were sent out. For the quarter ending December 31st, 1901, lymph was used for 261,044 cases, and showed a case success of 97 9 per cent., and an insertion success of 93 0 per cent. These cases are made up of:

	Cases.	Case Success.	Insertion Success.
Primary	126,209	Per cent. 98.6	Per cent. 94 0
Revaccinations ...	134,835	97.2	92.0

SMALL-POX IN GLASGOW—1900-1902.

By J. C. McVAIL, M.D.,

Medical Officer of Health for the Counties of Stirling and Dumbarton.

THE Medical Officer of Health of Glasgow, Dr. A. K. Chalmers, has issued a very valuable and interesting report on the recent prevalence of small-pox in that city. In noticing it we shall not attempt to touch on all the questions discussed by Dr. Chalmers, but shall refer only to certain of its more striking features.

Small-pox was introduced into Glasgow in April, 1900, and what Dr. Chalmers calls a pre-epidemic period continued until the end of that year. The total cases in this period were 397. Then, from the beginning of January, 1901, until the middle of July of the same year, there was an epidemic period in which the total cases amounted to 1,389. From the middle July until November there was no case of small-pox in Glasgow. Next, from November, 1901, up to the beginning of May, 1902, there has been what he describes as a period of recrudescence, the total cases in this period having been 469. No doubt even since the beginning of May there have been a few cases not included in the Report, but Dr. Chalmers has done wisely in not further delaying its issue.

Recent Revaccination in Glasgow.

It is well known that in Glasgow during the period reported on there has been a very large amount of revaccination with the purpose of preventing the spread of the disease. The total population over 5 years of age is set down as 675,887, and the total revaccinations performed from the beginning of 1901 up till May 3rd, 1902, are recorded as 404,855. All but about 8,000 of these were done in the year 1901, and the rest have been done in the first four months of 1902.[1] It is obvious that these data provide with regard to the value of recent revaccination a test which has never been equalled in this country in the extent of the population dealt with in a well-defined area in a short and definite time.

The question is: What has been the influence of these 400,000 revaccinations in the prevention of small-pox? There have been two great groups of population—one the Not Recently Revaccinated, and the other the Recently Revaccinated. To avoid needless detail Dr. Chalmers takes the whole population of Glasgow over 5 years of age at the beginning of the year 1901 as not recently revaccinated. In Table VIII, quoted below, he shows in successive fortnights from January, 1901, how this population gradually diminished in amount through transference to the group of recently revaccinated, until by May 3rd, 1902, the 675 887 had been reduced to 271 032. *Pari passu* he shows how the recently revaccinated whom he regards as *nil* at the beginning of 1901 have steadily mounted fortnight by fortnight until they reach the grand total of 404,855 on May 3rd, 1902. These are the populations dealt with, and now we come to the behaviour of small-pox towards them. Here also the facts are given fortnight by fortnight. The total cases (including for convenience some children under 5) from the beginning of January, 1901, till May 3rd, 1902, were 1,858. How many of these 1,858 cases occurred in the Not Recently Revaccinated and how many, on the other hand, were found in the population recently revaccinated? In the first fortnight, when the whole population is regarded as not recently revaccinated, of course all the small-pox occurred in that group. The cases were 23. By the second fortnight 1,071 people had been revaccinated. Of 350 cases of small-pox in that fortnight, all belonged to the first or greater group, and none to the 1,071 recently revaccinated. That might be accidental owing to the smallness of the latter group. In the next fortnight the recently revaccinated population amounted to 4,862, and the small-pox cases in Glasgow were 202. None of the 202 cases occurred among the 4,862. Possibly that also might be held to be a mere coincidence. By this time revaccination was going on apace, and in the fortnight ending February 23rd the recently revaccinated population amounted to 41,674. A fortnight later it had gone up to 119,326, and in yet another fortnight to 157,461. During those six weeks the total number of cases of small-pox was 587. How many of them were among the recently revaccinated?

The answer is, Not one.

The whole 587 belonged to those who had not yet accepted the protection offered to them. Still following Dr. Chalmers's table we find that revaccination continued to spread, so that by April 6th the recently revaccinated numbered 201,193, by April 20th, 246,831; by May 4th, 291,596; by May 18th, 309,762; and by June 1st, 323,254. During this time small-pox was on the decline, the cases fortnight by fortnight being 92, 67, 28 18, and 11, a total of 216. How many of these were among the now very large group of the recently revaccinated?

The answer again is, Not one.

From the beginning of June, 1901, onwards to the end of the year, there were very few cases of small-pox, and this fact corresponds generally with what is known of seasonal influence. The seasonal curves for London show that the first five months of the year are, outstandingly, the time for small-pox. From the beginning of June up to the middle of July there were only 11 cases in Glasgow, and these terminated the epidemic period. Once more the whole 11 belonged to the population who had not accepted revaccination. By this time that population was in a decided minority, as on July 13th the recently revaccinated numbered 394,020, and the not recently revaccinated were reduced to 218,867.

The great fact established by these very striking figures is

[1] Besides the above there were 8,001 revaccinations in 1900. *Vide infra.*

this, that during the Glasgow epidemic of small-pox in 1901, recent revaccination was an absolute protection against attack by small-pox. These two enormous groups of population in their relation to small-pox and recent revaccination teach a lesson so startlingly clear as to be utterly unmistakeable in its significance. Revaccination, successfully performed on persons who are not already in the incubation stage of small-pox, may be relied on with a certainty which is practically absolute, to protect against small-pox during such an epidemic as Glasgow experienced.

The figures, however, so far as we have gone, do nothing more than this. They have not given any indication of further duration of the protection. But the lesson does not stop here. From an epidemiological point of view it is a fact of great interest that, after an interval of four months, small-pox again showed itself in Glasgow, and that the period of recrudescence has continued at least up to the beginning of May of the present year. The next question is, Did the protection afforded by the recent revaccinations of the year 1901 continue in all the cases up till the beginning of May, 1902? Or was there by that time any very early indication of drift back towards susceptibility to small-pox? Were there any individuals among the 400,000 revaccinated who, owing to personal idiosyncrasy, or to the vaccinal operation not having been sufficiently performed, or to poor quality or long keeping of lymph, or to any other such cause were attacked by small-pox? Or, on the other hand, did the whole 469 cases of small-pox which belonged to the period of recrudescence, from the beginning of November, 1901, till the beginning of May, 1902, occur among the minority of people in Glasgow who had not yet transferred themselves to the group of the recently revaccinated?

The reply to the former question is No, and to the latter Yes. Not one of the 469 cases during the period of recrudescence occurred among the recently revaccinated majority. Every one of them occurred among the not recently revaccinated minority. The former remained absolutely free not merely from death by small-pox, but even from attack by small-pox. The latter had all the attacks and all the deaths.

Not Recently Revaccinated and Recently Revaccinated Population of Glasgow over 5 Years of Age in each Fortnight, with the Cases of Small-pox occurring in each Class.

1901.	Not Recently Revaccinated.		Recently Revaccinated.	
	Population.	Cases Registered*	Population.	Cases Registered.
January 12th ...	675,887	23	0	0
,, 26th ...	674,816	350	1,071	0
February 9th ...	671,025	202	4,862	0
,, 23rd ...	634,213	127	41,674	0
March 9th ...	556,561	299	119,326	0
,, 23rd ...	518,426	161	157,461	0
April 6th ...	474,694	92	201,193	0
,, 20th ...	429,056	67	246,831	0
May 4th ...	384,371	28	291,516	0
,, 18th ...	366,125	18	309,762	0
June 1st ...	352,633	11	323,254	0
,, 15th ...	347,777	2	328,110	0
,, 29th ...	345,293	8	330,594	0
July 13th ...	281,867	1	394,020	0
November 16th ...	279,452	1	396,435	0
,, 30th ...	279,232	5	396,655	0
December 14th ...	279,020	4	396,867	0
,, 28th ...	278,796	0	397,091	0
1902.				
January 11th ...	278,623	28	397,264	0
,, 25th ...	278,152	23	397,735	0
February 8th ...	277,653	23	398,234	0
,, 22nd ...	277,134	147	398,753	0
March 8th ...	276,033	92	399,854	0
,, 22nd ...	274,611	85	401,276	0
April 5th ...	272,694	36	403,193	0
,, 19th ...	271,619	15	404,268	0
May 3rd ...	271,032	10	404,855	0

*The cases under 5 years have not been excluded from these figures, because their allocation through the various fortnights would have been difficult, and their inclusion is unimportant. In the 1900-1901 part of the outbreak these numbered 60, 54 of whom (including 30 cases occurring under 1 year) were unvaccinated primarily.

In his report Dr. Chalmers explains that the returns of revaccinations were not always sent in quite regularly by the medical men. The statistics, therefore, showing the transference of population from the Not Recently Revaccinated to the Recently Revaccinated, are not to be regarded as absolutely, but only as approximately correct. If any critic of vaccination attaches importance to this, then we leave it to him to alter the figures in the population columns of the table as he pleases, provided he begins with the fact that on January 12th, 1901, the population Not Recently Vaccinated was 675,887, and that on May 3rd, 1902, it had been reduced to 271,032, while the Recently Revaccinated had increased correspondingly. If he thinks that on any particular date the population is wrongly distributed by 20,000, or 30,000, or 50,000, or 100,000, let him make the alteration to his own satisfaction, and then let him say whether the lesson taught by the table is appreciably affected. Take April 20th, for example, at which date Dr. Chalmers divides the population of 675,887 into two groups of 429,056 and 246,831. Our supposititious antivaccinationist may, if he pleases, take 100,000 off either group and add it to the other. That will not alter the essential fact that the whole 67 cases of small-pox in the preceding fortnight occurred in the first group and not one of them in the second.[1]

In the presence of such facts, is it still possible to argue that vaccination does nothing to prevent small-pox? The two groups constituted the entire population over 5 years of age of the infected city—the second largest city in the United Kingdom. The offer of vaccination was free to all. In some districts small-pox prevailed more than in others, and where it prevailed vaccination was the more resorted to, so that the recently revaccinated were specially exposed to attack. The working-class population of Glasgow live in large tenement buildings of three, or four, or five flats, each flat containing several separate dwellings opening into common passages or stairways. The strongest inducement to vaccination among these was the presence of small-pox in their midst. Some accepted the offer and some declined it. Fortnight after fortnight from the beginning of January, 1901, till the beginning of May, 1902, the experiment was repeated of allowing small-pox to differentiate between the Recently Revaccinated and the Not Recently Revaccinated. At the end of each fortnight the grouping was changed, a constant addition being made to the Recently Revaccinated, and a constant diminution taking place in the Not Recently Revaccinated. Whatever the numbers were in the two groups, the behaviour of small-pox with regard to them never varied, in respect that it persistently picked all its victims from the Not Recently Revaccinated, and as persistently refused to have anything to do with the Recently Revaccinated. To begin with, the opportunity of small-pox to attack the Recently Revaccinated was small. At the end of the first four weeks they numbered only 1,071. Four weeks later they had increased to 41,674, but small-pox still left them alone. In another four weeks a field of Recently Revaccinated, amounting to 157,461 persons, was spread out before small-pox but it refused to enter. In four weeks more the numbers were 246,831, but small-pox was not to be tempted. By February 22nd, 1902, the Recently Revaccinated had mounted up to nearly 400,000, and the other group had shrunk to less than 280,000. In the fortnight ending on that date small-pox had attacked 147 persons, but not one of these belonged to the 400,000. every case being taken from the reduced ranks of the Not Recently Revaccinated. As in Egypt long ago the angel of death passed by the houses of the Israelites whose lintels and door-posts were sprinkled with blood; so in Glasgow small-pox passed by those who had recently submitted to what antivaccinationists sneer at as the rite of vaccination. Wealth or poverty, cleanliness or dirt, drunkenness or total abstinence, youth or age made no difference to the Recently Revaccinated so far as small-pox was concerned. They remained immune right from the beginning of the epidemic to the end. The people lived together in these great tenements, subject to the same sanitary or insanitary conditions of water supply and drainage and refuse removal and house accommodation, their children attending the same schools, and themselves engaged in the same occupations. They differed only in this one respect—

[1] Also to avoid quibbling, he may, if he pleases, deduct from the total cases in the table a hundred or two to represent children under 5 years of age.

that some had submitted to revaccination and others had refused. Small-pox left the former class absolutely unscathed and found all its victims among the latter.

Having shown that recent revaccination did protect perfectly, both throughout the epidemic and throughout the period of recrudescence, we have now to ask whether the Glasgow epidemic furnishes any further evidence as to the duration of protection of revaccination. An answer is, so far, to be found in the fact that during the year 1900, in Dr. Chalmers's pre-epidemic period and prior to that covered by the table already quoted, there were 8,001 revaccinations performed in Glasgow. These remained entirely free from small-pox both in the epidemic of 1901 and in the period of recrudescence in 1902.

Still further evidence is afforded by such small-pox as did occur among those who had been revaccinated in Glasgow in periods earlier than the year 1900. During the epidemic of 1901 and the recrudescence of 1902, there were among the 2,255 persons attacked by small-pox, 19 who had been successfully revaccinated at some time or other prior to infection. The number of years which had elapsed between revaccination and attack by small-pox was as follows in these cases respectively: 55, 40, 32, 32, 31, 28, 27, 26, 21, 12, 11, 9, 8, 7, 6, 4, 4, 3, and 3. No particulars are given of the character of the scars left by these revaccinations, and it is unfortunate that no exact information is obtainable as to the total number of the population of Glasgow revaccinated prior to the year 1900 who contributed these 19 cases to the 2,255 cases constituting the epidemic. But it is well known that Glasgow is a city in which there has been much revaccination for many years. Opponents of vaccination, in referring to the recent outbreak, are never tired of quoting Dr. Russell's statement, made in 1897, that in Glasgow there had been "vaccination and revaccination to an extent unparalleled in any other locality." These 19 cases, however, were all that this revaccinated population of Glasgow contributed to the small-pox epidemic, and had the whole city been revaccinated there would have been no opportunity for the spread of small-pox in epidemic fashion.

Vaccination during the Small-pox Incubation Period.

Another question of interest is, In how many cases did small-pox develop within a fortnight of vaccination, the person being already infected by the disease before the protective operation was performed? The total was 126. In 6 of these the operation was not performed until the very day on which the individual sickened with small-pox; in 11 there was an interval of one day; in 3 an interval of two days; in 7 of three days; in 20 of four days; in 17 of five days; in 6 of six days; in 11 of seven days; in 13 of eight days; in 4 of nine days; in 1 of ten days; in 1 of twelve days; and in 1 of thirteen days. It thus appears that in all but 7 of the 126 cases the interval was eight days or less. The fact that these 7 were all that were to be found in a recently revaccinated population of over 400,000 is strongly indicative of the power of vaccination in very many cases to overtake or overcome small-pox if the operation is performed within a very few days after exposure to infection.

The Lymph used in Glasgow.

The Report gives no information regarding the brands of vaccine lymph that were used for the 400,000 revaccinations. Speaking roughly, lymph for about 350,000 of the 400,000 was supplied by the Corporation of Glasgow, the rest being obtained by medical men on their own account. We understand that it was all glycerinated calf lymph, and that it was not all supplied by any one maker or firm. The efficacy of these lymphs in preventing small-pox in Glasgow is certainly very strong evidence of the sound commercial morality and general reliability of private makers of vaccine lymph, and we are very glad to publish this fact. Nevertheless, we do not for one moment withdraw our opinion so frequently urged that all manufacture of vaccine lymph should be carried on under Government supervision. It is important not merely that lymph should be active, but also that it should be as free as possible from extraneous organisms, so that bad arms may be as few as possible.

Efficient Vaccination.

Nor does the Report give any information as to the number of marks or the insertion area of the 400,000 revaccinations. The opportunity to revaccinate on behalf of the local authority was offered to every medical man in Glasgow, and was accepted by a very large number. Whatever was the practice with regard to thoroughness of operative procedure, the results were sufficient to carry the protected individuals safely through the epidemic and its recrudescence. But it is generally understood that in Scotland the average standard of area and number of marks is not so high as in England, and this suspicion is supported by one fact mentioned in the Report. In January, 1901, when there was occasion, owing to the growth of the epidemic, to issue a second circular to practitioners asking co-operation in revaccination, the age-limit was reduced to 5 years "because of the number of children admitted [to hospital] with trifling vaccination cicatrices." While Scotland, therefore, is much in advance of England with regard to the numbers primarily vaccinated in proportion to the children born, in the important matter of efficiency of vaccination, as represented by area and number of marks, it is probably considerably behind England. If this be so, then there may well be an earlier average return of susceptibility to attack by small-pox in Scotland than in England, and it is fortunate that when small-pox does appear in Scotland, or at least when it seriously threatens a community, there is so very extensive a resort to the protection of revaccination.

We have already occupied so much space over this part of Dr. Chalmers's Report that it is impossible to do more than glance at the rest of it.

The Influence of Insanitation.

The question of the influence of insanitation in spreading small-pox in Glasgow is dealt with in the Report. For statistical purposes, Glasgow is divided into 34 districts. The general death-rate in Glasgow in 1898-1900 was 20.6 per thousand per annum. The following table gives the small-pox attack-rate in the six districts with the highest general death-rate, and also gives the general death-rates in the Eastern Division of the city in which small-pox mostly prevailed.

District.	Deaths per 1000 from all Causes.	Small-pox Attack-rate per 1000.
13 Brownfield	33.06	2.5
16 Cowcaddens	32.79	1.0
6 High Street and Closes East ...	30.43	2.9
2 Port Dundas	29.55	0.3
22 Gorbals	28.89	1.8
3 High Street and Closes West ...	28.62	0.3
Glasgow	20.6	2.3
Eastern Division.		
7 Greenhead and London Road ...	22 0	9.9
8 Barrowfield	25.7	6.4
5 Bellgrove and Dennistoun ...	19.0	2.8

Another table gives for these same districts the infantile, the zymotic, and the respiratory death-rates, as follows:

District.	Death-rate under One Year Per 1,000 Born.	Death-rate per Million.		
		Zymotic Diseases.	Respiratory Diseases (not Phthisis).	Small-pox.
13 Brownfield	207	5,303	8,934	—
16 Cowcaddens	218	5,033	9,379	220
6 High Street and Closes East	198	3,839	5,394	282
2 Port Dundas	224	4 288	8,150	—
22 Gorbals	209	4,768	7,487	153
3 High Street and Closes West	177	3,262	6,597	103
City	153	3,153	4,617	307
7 Greenhead and London Road	152	4,319	4,826	1,103
8 Barrowfield	180	4,813	6,510	939
5 Bellgrove and Dennistoun ...	142	3,185	4,104	442

These figures, so far as they go, give no support to the view

that small-pox selected the most insanitary districts for its field of operation in Glasgow.

Hospital Statistics.

Referring now to experience of small-pox and vaccination in Belvidere Hospital, Dr. Chalmers's Table VI teaches the

TABLE VI.—*Glasgow.—Small-pox, 1900-1.—Return as to Vaccination of All Cases Treated in Belvidere Small-pox Hospital from April 1st, 1900, to June 30th, 1901.*

Age.	Vaccinated.			Unvaccinated.			Vaccination Doubtful.			Total.		
	Recovered.	Died.	Mortality per cent.	Recovered.	Died.	Mortality per cent.	Recovered.	Died.	Mortality per cent.	Recovered.	Died.	Mortality per cent.
Years.												
0—5	2	1	33.3	18	36	66.6	3	—	—	23	37	61.7
5—10 ...	31	—	—	10	2	16.7	2	—	—	43	2	4 4
10—15... ...	92	1	1.1	10	4	28.6	1	1	50.0	103	6	5.5
15—20	131	—	—	4	2	33.3	1	1	50.0	136	3	2.2
20—25... ...	242	12	4.7	2	4	66.6	1	2	66.6	245	18	6 8
25—35... ...	584	42	6.7	6	5	45.8	4	9	69.2	594	56	8.6
35—45... ...	291	51	14.9	8	4	33.3	5	6	54.5	304	61	16.7
45—55... ...	91	26	22.2	1	6	85.7	3	4	57.1	95	36	27.5
55—65	18	13	41.9	—	—	—	1	1	50.0	19	14	42.4
65 and over	10	4	28.6	—	—	—	—	1	100.0	10	5	33.3
All ages ...	1,492	150	9.1	59	63	51.6	21	25	54.3	1,572	238	13.1

This table includes cases from beyond city boundaries.

usual lessons (1) that small-pox among the vaccinated is nowadays mainly a disease of adults, because children are protected by primary vaccination, and renewal of protection is greatly neglected; (2) that among the unvaccinated small-pox is still in great measure a disease of the young as it was in pre-vaccination times; and (3) that the fatality-rate among the vaccinated is at all ages much less than among the unvaccinated, and that this difference is more striking in children because of the recency of their vaccination. It will be observed from the table that two deaths occurred among 258 vaccinated persons under 20 years of age. One of these two was between 10 and 15 years old. The other was a child of 2 years old, "whose vaccination mark was 0.04 of a square inch in area and was glazed and not foveated."

The Scottish Vaccination Act of 1863 came into force in 1864. In Glasgow there was an epidemic in 1855-57. At that time 88.8 of the small-pox deaths occurred in children under 10 years old, and only 11.2 per cent. in persons over that age. Then Glasgow in 1870-72 had its share of the pandemic of the early Seventies. By that time the Vaccination Act had had from 6 to 8 years in which to protect children born since 1863 and the percentage of the total small-pox deaths contributed by children under 10 years of age was reduced from the 88.8 per cent. of 1855-57 to 38.5 per cent. in 1870-72. For many years the amount of default of primary vaccination in Glasgow has averaged only about 3 per cent., so that the recent epidemic found the great bulk of the youthful population primarily vaccinated. That being so, the children under 10 years of age, who contributed 88.8 per cent. of the total small-pox deaths in the first of these three epidemics, and 38.5 per cent. in the second epidemic, have now (in 1900-1) contributed only 16.4 per cent, no less than 83.4 per cent. of the cases being over 10 years old. There can be no doubt whatever that if the average efficiency of primary vaccination in Glasgow, as represented by number and area of marks, had been as high as it ought to be, the contribution made by children under 10 would have been a good deal less than even 16.4 per cent.

Hospital Influence.

An important question which we can do no more than mention here is that of hospital influence in the spread of small-pox in Glasgow. In the epidemic of 1870-2 Glasgow treated its small-pox in Parliamentary Road Hospital, and at that time there was a great aggregation of cases of the disease in the population surrounding that institution. Belvidere Hospital, where the disease has been treated in recent years, is in the east end of the city, and the eastern division has had very much more than its share of small-pox cases. There can be no doubt that this adds another to the many well-known examples of the influence of small-pox hospitals in spreading the disease in the surrounding population. The Corporation of Glasgow will, it may be assumed, give very serious consideration to the evidence adduced by Dr. Chalmers on the evil effects of Belvidere Hospital during the late epidemic. What remedy they may ultimately adopt, we know not. Meantime, however, we would desire to point out this to them. Among the 400,000 persons recently revaccinated there was not a single case of small-pox. If the remaining portion of the city had been similarly protected there would have been no case of small-pox in Belvidere, and not a single hospital bed would have been required for the treatment of that disease. This does not mean that all the 270,000 of population over 5 years old not recently revaccinated should have been revaccinated at the time of the epidemic. Of the total census population 79,821 were between 5 and 10 years old. If primary vaccination were done as efficiently in Glasgow as it ought to be done, these would be excluded from any need for revaccination, and this would make a reduction of the 270,000 population in question to about 190,000. Very many of these had already been revaccinated at some time or other, and we have seen that they contributed only 19 cases to the epidemic. In short, if all had been revaccinated only once in their lives there would have been no epidemic. As it is, those who have taken the trouble to protect themselves have also had to contribute their full share to the Belvidere Hospital expenses, and if new hospitals are to be built they will be similarly mulcted.

Very soon the subject of vaccinal legislation in England must again come before Parliament. If Glasgow wants to get rid finally of all the worry and of very nearly all the expense of small-pox hospitals, it should urge its representatives in Parliament to support the policy of getting revaccination at adolescence put on the same legislative footing as primary vaccination of infants, so that exactly the same pressure may be brought to bear on revaccination of children about to leave school as on the vaccination of infants within six months of their birth.

VACCINATION WITH GLYCERINATED CALF LYMPH.

BY ALBERT E. COPE, M.D.DURH., M.B.LOND., D.P.H.

WHILE it may be given to few to explore the pathology and bacteriology of small-pox and vaccination, or to investigate their history and statistical relations, there are two questions of the utmost practical importance, and of very general interest, which recent legislation has brought into prominent relief. What method should we adopt, and what results may we observe, in the employment of glycerinated calf lymph for human vaccination and revaccination?

The Vaccination Order of 1898 has wisely contented itself with laying down certain general principles, leaving it to the initiative of each vaccinator to apply them. Thus the public vaccinator is instructed that "Vaccination should at every stage be carried out with aseptic precautions. These should include (1) the cleansing of the surface of the skin before vaccination; (2) the use of sterilized instruments; and (3) the protection of the vaccinated surface against extraneous infection both at the performance of the operation and on inspection of the results."

It will be my object to briefly outline some of the methods which may be adopted, and some of the results which may be observed, in the hope that others may be stimulated to give the benefit of their experience, and that an increasing simplicity in our methods may yield more uniformity in our results.

We will suppose then that a child is before us for vaccination. Our first duty is to assure ourselves that the child is fit to be vaccinated. Generally speaking the mother will be quick to let us know of any abnormal condition, but it is none the less important to confirm our general impression of the well-being of the child by an examination of the skin, especially behind the ears and in the napkin area, for evidences

of intertrigo or flexural eczema, excluding also condylomata or fissures round the anus. Extensive lichen urticatus or strophulus, especially when associated, as is so frequently the case, with digestive disorder will lead us to postpone vaccination, as also will any impetigo or syphilitic roseola. Elevation of temperature will contraindicate vaccination, whether due to bronchial or intestinal catarrh or other cause, and infantile atrophy or marasmus, it being a safe rule not to vaccinate a child which is losing weight. It will also be necessary to postpone the operation if there is any infectious disease in the family, and wise to do so even if there should be danger of contamination from pus of mammary abscess or ulceration of the leg.

Having examined the child and its surroundings, we have next to cleanse the arm. The morning bath has already come to our help in this respect, but is not sufficient, and we proceed ourselves to wash over the outer aspect of the left arm, which should have been taken completely out of the clothing. What can we use? Either water, or lotion, or spirit. If water, then we get it from the kettle which has just boiled, or we boil a little ourselves in one of the compact little appliances which all instrument makers keep, or we carry a bottle of freshly boiled water in our bag. We use with the water some form of soap, either plain, or, better, antiseptic, and either in cake or in liquid form. Thus the terebene liquid soap, the ether or ether-mercurial soap, the mercurial so-called germicide soaps, and, best of all, the 20 per cent. carbolic acid soap, as being detergent, antiseptic, and grease-removing, have all their advocates. The washing should be done with aseptic or antiseptic wool or tow, and any excess of antiseptic should be removed by washing off with plain boiled water, the area being then dried with another pledget of wool. Instead of soap and water we may use weak antiseptic lotions, mercurial, carbolic, formalin, listerine, but we have to be careful in the use of mercurials, as experience with calves and in human vaccination shows that it is difficult to remove any excess from the skin, and there is danger of the vaccine being inhibited.

In the case of infants it usually will suffice to wash vigorously with rectified spirit, and then dry with pledgets of boric wool or wood wool. This is detergent, and removes grease, is mildly antiseptic, and determines a flow of blood to the surface of the skin, which is desirable for the rapid absorption of the virus. Methylated spirit is objectionable because of smell, and as only small quantities are required the difference in cost is unimportant. In the case of revaccinations, I prefer myself a double washing—first with the carbolic soap and water, then with spirit, and lastly drying, all with boric acid wool pledgets. The spirit is conveniently carried in a bottle with an indiarubber cork, perforated for the reception of a fitting such as is used in ordinary scent bottles.

The skin being prepared, we must choose an instrument. Here, also, there has appeared to be scope for considerable ingenuity, but ingenuity counts for nothing beside safety, simplicity, and efficiency. The various forms of tortoiseshell-handled bleeding-lancet vaccinators are still largely used, though metal handles which can be detached and sterilized completely by boiling may conveniently be substituted.

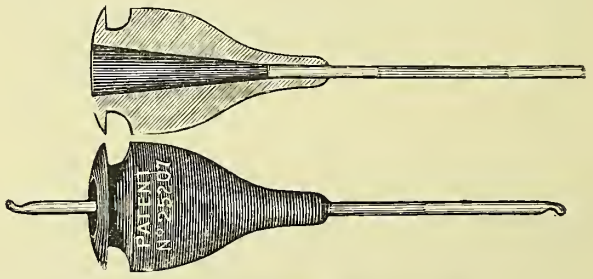
What are the requisites for scientific vaccination?—

1. An instrument which can be completely sterilized. This puts out of court all the elaborate automatic vaccinators, and many of those with projecting needles. The sterilizing may be by flame, which is in all cases preferable. The temper of steel will be injured, but as we do not need a cutting instrument so much as a scratching one this will be of little consequence. With our spirit bottle, a pledget of wool, and a match stalk, or even the empty capillary tube to make a torch, the process is easy. If boiling is preferred, soda or borax may be added to the water so as to prevent rusting. Antiseptic lotions may be employed instead. The very best vaccinating instrument from this point of view is the palatinum iridium lancet or needle, which may be flamed a thousand times and yet be as bright and almost as good as at the beginning.

2. An instrument with one point. Nothing is so free from precision as vaccination with an instrument, however easily sterilized, which has three or four points; and nothing is so likely to offend the maternal instinct as the sight of four groups of two or three vesicles which she speaks of as "vaccination in ten places," a result which it is difficult to avoid in vaccination with such an appliance. The success which it has achieved in the hands of many is simply an evidence of skill on the part of the vaccinator, just as one man may succeed in driving a four-in-hand where another would lamentably fail with a pony and trap.

3. An instrument with a good handle. The vaccinator who has much to do will avoid the needle or pin vaccinator, although it is easily sterilized or thrown away. He does not want to add to the already formidable list of diseases, a "vaccinator's" cramp.

My vote then is given for a platinum double-edged lancet similar in shape to a Paget's abscess knife, with a steel handle, such as is used for ophthalmic knives, all in one piece, the blade sterilized by spirit flame. One special advantage of this type of instrument is that the blade may be made white hot in half a minute, and the parent may see the sterilizing before her eyes. Now, as for the emptying of the capillary tube. For the ordinary tube containing sufficient for one vaccination, and of about 1 to 1.5 mm. external diameter, nothing is better than the pear shaped solid red rubber boilable ejector with funnel-shaped perforation. The tube is



Vaccine ejector (Montague, New Bond Street).

passed through the perforation, both ends broken off between finger and thumb of each hand (or by special breaker), any fragments of broken glass released from the ends; the tube is then drawn on till it becomes the stalk of the pear, the pear is held between first and second finger of left hand, thumb over wide end, when pressure of the thumb compresses air in funnel, and drives out lymph on to the lancet. The same ejector may be used for much wider tubes, but is not so satisfactory if the external diameter is much less than 1mm. Several similar ejectors are made in which a small rubber ball takes the place of the funnel-perforated solid rubber, others on the principle of a bellows with very fine rubber tubing on the nozzle, or a hypodermic syringe or fountain pen filler with similar fitting.

It is better not to blow the lymph on to the skin but on to the lancet, and then place the lymph on the cleansed arm in four places in the form of a square or diamond, with the deltoid insertion in the centre, the sides of the square being about 2 to 2.5 c.cm. All is now ready for the actual vaccination. The operator's left hand is passed under, and holds the arm firmly, putting the skin on the outer aspect on the stretch. Holding the lancet recommended, as a pen, but somewhat more perpendicularly, the blade being used in the cutting direction and not so as to turn the point, two or three light scratches 5 mm. long are made through each droplet of lymph, and with the flat of the blade the lymph is gently pressed into the scratches. It is extremely rare for blood to flow, although one tries to get a tiny point of blood in each scarification. It is also very rare for the scratching to make the child cry. Within two minutes in most cases the edges of the scratches become tumid and on stretching the skin one can distinctly see an urticarial effect. The lancet is wiped with boric wool, sterilized at once, and put back in its case.

Now, what is to be done to protect the places from contamination? The plan which I almost invariably adopt is to take a pad of boric wool 3 in. by 2 in., place it over the vaccinated area with the long axis vertical, and fix it in position by two 10 to 15 c.cm. (4 in. to 6 in.) strips of $\frac{1}{2}$ in. rubber adhesive plaster (sold in ten yard spools) making sure that the plaster will be clear of the vesicles, and that the upper strip is fixed solely to the arm, and not to the axillary

folds. The boric wool should answer the test of giving a distinct green flame when lighted after soaking with alcohol, but should not be heavily weighted with the antiseptic. This method, however, is not perfect and is simply one among a vast number which have sprung into use within the last few years. We may classify the methods thus—

(*a*) The antiseptic tissue, film, taffetas, or goldbeaters' skin, one side coated with dextrin or other adhesive material. The skin around the points of vaccination is moistened, and the film pressed over the whole area.

(*b*) The aseptic pad, contained, with a gauze sponge for washing the arm in a germ-proof bag of gamgee tissue, affixed to the skin by tapes or by an oval of plaster.

(*c*) The antiseptic pad, which is probably the most popular and generally useful form of dressing.

Hartmann's wood-wool pads have easily led the way in this department, but are being run very closely by other makers. The pad may be impregnated with any ordinary antiseptic, and may be affixed with tapes or plaster. A very useful pad has just been introduced which has a strip of plaster at the top and gauze tapes below, so that the vesicles may be uncovered without removing the pad, and the surface dusted with any soothing powder.

(*d*) Collodion may be used. M. Chambon, of the Institut de Vaccine Animale, Paris, first removes the excess of glycerinated lymph with weak boric lotion, and then a sterilized brush of cotton wool twisted round a sort of match stalk is dipped into collodion and applied to each insertion.

Tegmin is another preparation recently introduced from Vienna in sterile collapsible tubes, which may be applied directly to the scarifications, and dries rapidly.

Boric gelatine and similar applications have their advocates. In all these cases probably an antiseptic pad would in addition be advisable.

So far, then, for our methods of vaccinating. What results may we expect to obtain from the use of glycerinated calf lymph? The results are not, cannot be, uniform, but will depend upon: (1) The character and age of the lymph; (2) the idiosyncrasy of the person vaccinated; (3) the state of the person vaccinated in regard to previous vaccination.

It is only possible, therefore, to give general indications as to the course of the development of the vaccination. One may roughly say that the total duration of a normal vaccination from operation to falling of scab is twenty-one days; this period being divided into two equal parts corresponding to the evolution and the involution of the vesicles. French writers are fond of speaking of a period of incubation followed by the periods of eruption, maturation, desiccation, and cicatrization. The use of the term "incubation" is rather ambiguous, however, as the vaccine has a continuous and progressive effect from the time of its introduction to the lymph spaces of the skin, and there is no clear demarcation of stages, the word incubation being used simply to express the sum of changes up to the distinctly papular or early vesicular stage. Furthermore, the use of the term incubation in this sense tends to confuse the parallelism which exists between ordinary variola, inoculated variola, and vaccinia, the incubation stage in the two former signifying the period up to the commencement of constitutional symptoms, a period with a less definite, but none the less real, existence in the case of the last-named.

Thus the incubation stage of small-pox is twelve days, of the inoculated variety eight days, while the general symptoms after vaccination appear usually between the sixth and eighth days in the form of restlessness, and slight elevation of temperature, with development of areola around vesicles, and go on in a variable number of cases to the appearance of an exanthem between the ninth and eleventh days. The word incubation therefore, in my opinion, should be reserved for the period up to the commencement of general symptoms, and should not be used in the description of the local lesion at all.

There is another word in respect to which ambiguity is apt to arise, that is, the word "day." It should be distinctly understood that when the end of the fifth day is spoken of the end of five complete periods of twenty-four hours is meant. For example, the calf vaccine is collected at the end of five days (120 hours) from the vaccination of the calf.

During the first day or two the results of the mechanical injury are more evident than those of specific infection. The immediate result of the operation is to divide the cuticle, and just scratch the true skin, tearing across small capillaries and giving rise to tiny haemorrhagic points in the lines of scarification, with vasodilatation and tumefaction which in a minute or two becomes distinctly urticarial in appearance, especially if the skin is put lightly on the stretch. With active lymph the scratch thus made never becomes "dead" like an ordinary scratch, but right from the commencement a little flush is seen, and a little papular elevation is apparent which serve to show that the lymph is taking. In the primary vaccination of children who are old enough to be able to appreciate it a little itching is noticed from the very first day. By the beginning of the third day it is not uncommon to find the scratch in a flat-topped papular condition, like as if a line of lichen ruber planus had been run along the skin. The end of the fourth or beginning of the fifth day will show this papular condition becoming distinctly vesicular with a depressed line in the centre corresponding to the line of scarification. Up to this stage the surface of the vesicle has been a very delicate pale rose pink with a deeper pink skin margin, but at this point the separation of the epidermis from the vascular part of the skin by the further development of the vesicle gives the surface a blue-white, opalescent, pearly appearance outside which is the pink ring which increases from the fifth to the tenth day and is called the areola. The breadth of the papule on the third day is from 1 to 2 mm., and of the vesicle on the fifth day 3 to 4 mm.

The careful investigation of the histology of the vaccine lesion in the calf as reported by Drs. S. M. Copeman and Gustav Mann in the Supplement to the Twenty-eighth Annual Report of the Local Government Board, has thrown considerable light upon the character of the changes which produce the vesicle which is now formed. Briefly, it may be said that the central depression marks the position of the external and internal clot and local necrosis following the immediate mechanical and chemical injury to the skin tissues by the process of vaccination. The vesiculation is really a distension of the intercellular lymph spaces of the Malpighian (prickle-cell) layer of the epidermis, groups of epithelial cells being converted into the walls of a sponge-like intercommunicating system of lymph spaces which break into one another, forming bullae filled with vaccine lymph. One would, therefore, no more expect the vesicle to collapse on puncture than one would expect a sponge soaked in gum to do so. Puncture, however, will be followed by the exudation of some of the lymph, which will coagulate on the surface of the vesicle, if left dry, and seal up the wound.

By the seventh day the breadth of the vesicle may be 5 or 6 mm., and we observe that, while the margin still retains its glistening, translucent, pearly character with the thin pale-red areolar line around it, the rest of the surface presents a more opalescent bluish-white appearance, the base is distinctly indurated as felt between finger and thumb, and the whole vesicle is more prominent, with commencing engorgement of the axillary lymphatic glands and flattening of the axillary hollow. The temperature may be raised a couple of degrees at the end of this day, and this is the point at which it was usual to collect lymph for arm-to-arm vaccination by puncture of the pearly margin of the vesicle. From this point also to the eleventh day the areola develops, first (eighth day) as a patchy redness with papular spurs reaching out from the red margin of the vesicle, like the mountain spurs which buttress a plateau; later (tenth day) there may be coalescence of the areolae of the four vesicles, and fusion of the areas of induration which form the bases of the vesicles, so that the separate vesicles cannot be held between finger and thumb, but the whole vaccinated area forms a prominence on the outer side of the arm from which the vesicles stand out.

While the areola is developing important changes are taking place in the vesicle itself. On the ninth day we may notice, in addition to the pearly margin, and the duller bluish-white surface, a dead yellow-white centre, frequently with epidermal débris. This is due to the coagulation and necrosis of the central elements of the vesicle (lymph and cells), and the process thus commenced spreads from centre to circumference, the course of necrosis being marked by deepening coloration from ochrey-yellow, through burnt sienna or burnt umber of deepening shades, with a frequent admixture of purple or violet-brown, to the final black-brown

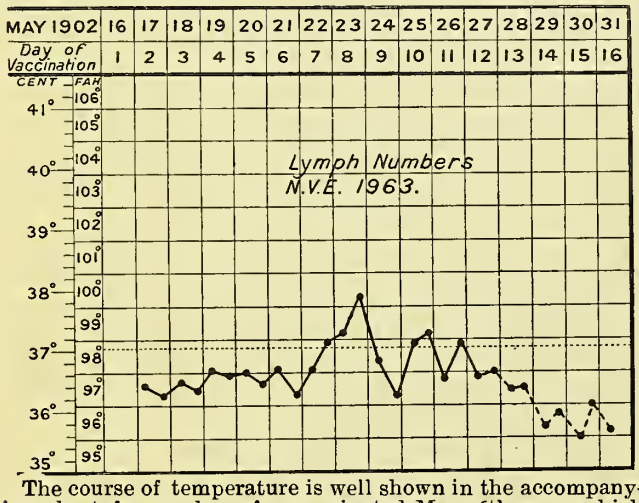
scab, these colour changes being completed usually within the second week (ninth to fifteenth days).

The areola attains its maximum on the tenth day, and quickly subsides, leaving a dull purple-red coloration of the skin, with delicate, lace-like desquamation immediately round the vesicles, the induration of the base passing away, also, very rapidly, leaving the skin flat and supple.

The size of the vesicle, on the ninth day, 7 to 8 mm., may reach a maximum of 1 cm. on the tenth or eleventh day, but does not usually advance after that. The pearly edge loses its lustre on the ninth or tenth day, and about this time one frequently observes the desquamation of the superficial layers of the vesicular epidermis, which brings the original stratum lucidum to form the surface of the vesicle.

The changes which follow this are not visible, but consist, according to Dr. Cory, of an ingrowth from the stratum lucidum dating from the tenth day, which gradually cuts off the scab at its base. As a matter of fact, were it not for the commencement of immunization, there is no reason why the vesicle should not spread centrifugally until all the skin had been invaded, just as one finds a tendency on the part of all fungoid skin conditions to spread. As soon as immunization commences, the scab begins to be a foreign body, and is removed just in a similar fashion to the mummified umbilical cord when its function has been accomplished. One occasionally meets with interesting cases in which the immunizing process appears to be delayed, and the vesicle keeps spreading, sometimes with the formation of supplementary vesicles at the periphery until quite a large area is involved, the appearance being not unlike that figured in some of the plates of inoculated small-pox. Generally in these cases the constitutional symptoms are not more marked than in an ordinary vaccination, and the only danger is that the period of healing is delayed, and thus the opportunities for injury and secondary infection are increased. Dr. Cory found that on the average of a considerable number of cases the scab fell on the twenty-first day, leaving the skin completely healed, and a depressed pink scar, which in the course of a few months became the white vaccination scar with which all are familiar.

It should be added that from the ninth to the twelfth days after vaccination one occasionally sees a rash on the skin, about the nature of which doubt has arisen. While the vaccine roseola may be simply a toxin rash similar to the antitoxic rashes or the rheumatic or digestive erythemata, there is some reason for considering it the true analogue of the secondary rash which appears on the eleventh day after small-pox inoculation.



The course of temperature is well shown in the accompanying chart from a boy of 9, vaccinated May 16th, 1902, which was kindly obtained for me by the Lady Superintendent of the Westminster District Nurses.

Such is the course of an ordinary primary vaccination. What difference does the fact of a previous vaccination make?

First, it should be recognized that the immunizing effect of vaccination appears to be much more rapidly destroyed, as would naturally be imagined, during the first fifteen years of life, the period of transition from infancy through childhood to puberty, than in any subsequent period of fifteen years. Thus, while revaccination of a child of 10 to 15, successfully vaccinated in infancy, will yield in many cases vesicles of good size, revaccination in an adult, within ten or fifteen years of a successful primary vaccination, will not usually reach more than a papular or very poor vesicular stage. This is important from the point of view of general revaccination, for while a primary vaccination may require repetition within ten or fifteen years, there will not be the same urgency for a second repetition of the operation.

Revaccination with the same lymph as produces the effects described above as characteristic of primary vaccination, within five to ten years of previous successful vaccination or small-pox in an adult, gives rise to itching on the first day, the formation of an inflamed irritable elevated scratch on the second and third days with a little axillary tenderness, and by the end of a week all that can be seen is a red line corresponding to the scratch, which may persist for some weeks. Revaccination within ten or fifteen years of a previous successful vaccination gives rise generally in the adult to a distinct papule which may become vesicular, and form a small scab which falls in the second week. If more than fifteen years has elapsed the results approximate more nearly to a primary vaccination, as the length of interval increases. If, however, we are vaccinating for the first time since an infantile vaccination it is possible to get small vesicles at 7 years of age, and large vesicles at 14, especially if the infantile vaccination has been of poor quality. If, however, there are four or five good marks, the vaccination is generally abortive until the twelfth to fourteenth year.

Revaccination presents one or two features of some importance which demand passing notice. First, there is much more tendency to oedema of the distal part of the limb, commencing near the vesicles, and spreading with definite ridge-like margin to just above the elbow, then just over the origin of the supinators, then the mid-forearm, and, lastly wrist and even hand. This oedema subsides, in some instances very suddenly, especially if one orders the hand to be supported by a sling, and foments the axilla with hot water, for the axillary glands appear to be the key of the situation. It is only important because it is sometimes mistaken for cellulitis. It is not uncommon to find the general symptoms taking [on an influenzal or rheumatic character, and in one or two cases temporary cardiac *souffles* have been audible, the whole passing off with simple antifebrifuge treatment. It is important to recognize that revaccination after twenty years is generally accompanied with constitutional symptoms, which demand the same kind of care as if one had a bad cold. It is one of the strongest arguments for compulsory revaccination at the close of school life that, if left till adult life is reached, revaccination is a distinctly more troublesome business, and it is frequently impossible to take the precautions which prudence would suggest.

The same lymph, then, will produce very different results according to the state of the patient in respect of previous vaccination or small-pox, and it is very useful to check the results of revaccination by a parallel series of primary vaccinations, so that we may have assurance as to the activity of the lymph used. For it is equally true that lymph may be variable, and variable results may own this as their cause, a veritable *fons et origo mali*. Inert lymph—how much it has had to answer for. The certificates of insusceptibility, which in the last annual return numbered over 3,000, are almost all to be put down to its credit. It is not yet sufficiently widely known that if one vaccinates calf or child with inert glycerinated calf lymph, lymph which has even been sterilized by heat, there is apparently an absorption of toxin sufficient to temporarily inhibit the success of a further vaccination even with active lymph. The practice, therefore, of vaccinating immediately upon evidence of failure of a first vaccination is almost certain to lead to failure a second time. It is necessary to wait at least one month, and preferably two months before making a second attempt. It is questionable whether the temporary immunity extends to protection against small-pox.

Lymph of feeble activity is also responsible for the group of cases known by French authors as "vaccine rouge," in which, in place of the normal vesicle, a fleshy, red, naevoid

Fig. 1.—SMALL-POX MODIFIED Seventh day of eruption.

Fig. 2.—SMALL-POX—UNMODIFIED. Third to fourth day of eruption.

Fig. 3.—CHICKEN-POX. Adult. Second day of eruption.

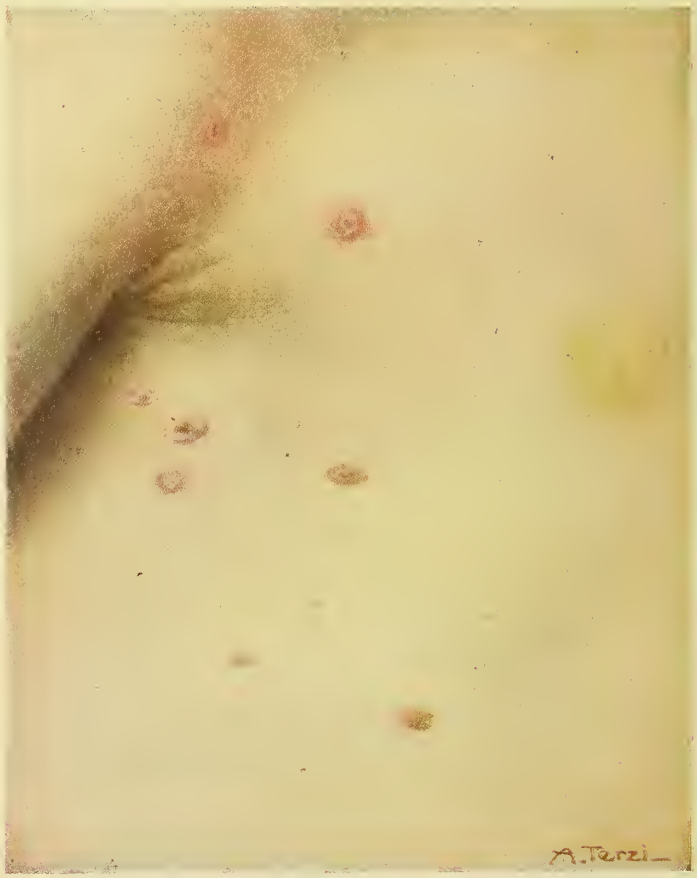


Fig. 4.—CHICKEN-POX. Child aged 7. Third day of rash.

Fig. 5.—VACCINATION. Fifth day.

Fig. 6.—VACCINATION. Eighth day.

Fig. 7.—VACCINATION. Twelfth day

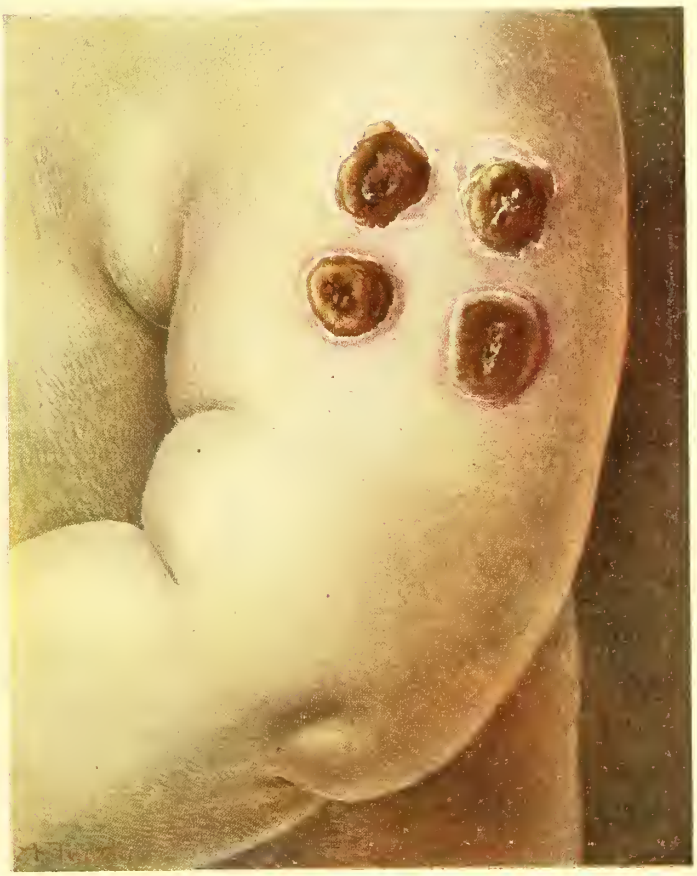


Fig. 8. -VACCINATION. Fifteenth day.

tubercle appears on the site of vaccination, which passes off in the course of a week or month, but which appears to have no protective influence.

I have not made any reference to the complications which may mark the course of a vaccination and their treatment. The various methods of protecting the vaccine vesicle have very largely diminished the risks of the operation, a result which was anticipated in the report of the Royal Commission. If only the vesicle can be kept free from mechanical injury, or, when injured, if exudation can be checked and the ingress of organisms prevented until the scab, kept perfectly dry, has fallen, leaving the typical scar, we shall have little fear of any complications.

One method which I have found of exceptional value, and which I believe is worthy of wide adoption, is the use of a saturated aqueous solution of picric acid to paint over the vesicles and surrounding skin, wherever there has been any such injury to the vesicles. I was led to try this from an observance of the value of the same application in the some-

Fig. 1.—Diagram showing distribution of eruption in small-pox. (To illustrate Dr. Wanklyn's paper.)

what similar condition after burns and scalds. The application is painless, and I have simply covered it with antiseptic wool, leaving it untouched for several days.

In conclusion, it is necessary to add that the description of the course of the vaccination is an attempt to give a composite picture of the course of a process which is distinctly variable, both by acceleration and retardation and in intensity, and that it is gleaned from the use of the lymph issued by the National Vaccine Establishment, which has been remarkably uniform in its results for some time.

While the writer is probably as sensible as any one of the lacunae which remain to be filled up, his main object has been to open up two lines of investigation to which every one who vaccinates may contribute some facts from his own experience, by the pursuit of which the risks of the operation may be reduced to a minimum, and yet which are but scantily represented in easily accessible medical literature.

DESCRIPTION OF COLOURED PLATES ILLUSTRATING DR. COPE'S PAPER.
(Between pages 44 and 45.)

Fig. 5.—Child, W. L., male, aged 6 months. Appearance at beginning of fifth day. Situation of individual scratches indicated by depressions in the developing vesicles. Faint flush round each vesicle.

Fig. 6.—Child, D. C., female, aged 10 months. Appearance at beginning of ninth day, but somewhat delayed, and would pass quite well for eighth day, except that surface of vesicles is dull.

Fig. 7.—Same child, D. C. Appearance at end of twelve days. Two supplementary vesicles on arm. Course of development unusually rapid between ninth and twelfth days in this case, desquamation being active around vesicles, the surfaces of which have darkened right to the edge, though there are patches where the vesicular edge is still visible.

Fig. 8.—Child, J. S., male, aged 4 months. Appearance on fifteenth day. The lower right-hand vesicle has not advanced so rapidly as the rest, and shows more typically than Fig. 3 the more usual method of desiccation of the vesicle.

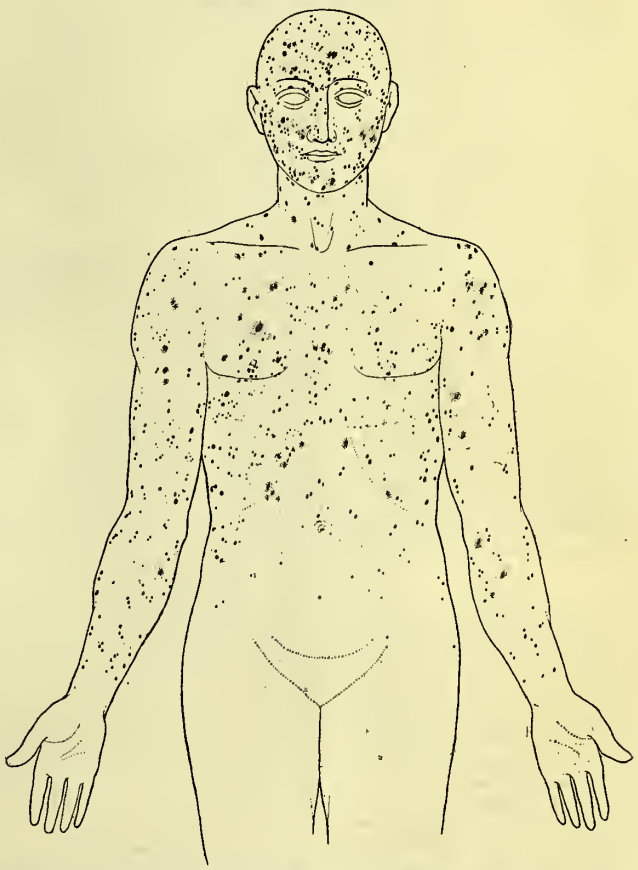


Fig. 2.—Diagram showing distribution of eruption in chicken-pox (To illustrate Dr. Wanklyn's paper.)

DIFFERENTIAL DIAGNOSIS BETWEEN VARIOLA AND VARICELLA.

BY W. McCONNEL WANKLYN, B.A.CANTAB., M.R.C.S., L.R.C.P.,
Small-pox Referee and Medical Superintendent of the River Ambulance Service of the Metropolitan Asylums Board.

FEW problems in diagnosis have been of more practical importance recently than the differentiation between variola and varicella. The following remarks are based upon the observation of 200 cases of varicella sent to the diagnosing station of the Asylums Board during the recent outbreak of small-pox. Since these cases were sufficiently puzzling to be taken for small-pox, it will be of interest to touch upon the distinctive features of the two diseases, and indicate those which led to a correct diagnosis being made.

History.

An accurate history is a rarity. The following is an example:

Day 1.—A. B., male, aged 20, taken ill acutely with fever. Temperature 102°; *malaise*; general aching and shivering.
Day 2.—Pyrexia continued: *malaise*; patient is unfit for work.
Day 3.—General improvement: papules noticed on chin in evening.
Day 4.—The patient is certified to have small-pox, and comes under observation; an abundant eruption is present. The case was found to be varicella.

The similarity of this history to that occurring in many cases of variola is apparent. Yet such a history is not uncommon in adult varicella, and the example shows of how little value in diagnosis an accurate history may be.

Commonly the history is inaccurate.

The facts of the illness before it comes under observation are so ill observed and ill recorded that as evidence they are of little positive value; in addition they are often misleading. As a matter of practice it is wise to disregard and refuse to hear the history till the first-hand evidence is noted and weighed. After an opinion has been formed thereon the history may be taken into account and considered with caution. To attach much weight to history is certain to lead to error. In no class of case than those under consideration is the dictum of the late Sir G. M. Humphry to his students more applicable, "Eyes first and most, hands next, tongue last and least." The value of the first-hand evidence outweighs altogether that derived from the history.

Age.

This is seldom a point of much practical value in diagnosis. Of the 200 cases of varicella alluded to, 16.7 per cent. were over 18 years of age. Doubtless the lighter incidence among adults is due to the same causes which lead to a light incidence in scarlet fever and measles—namely, the protection afforded by attacks in youth, absence of close contact between adults and infected children, and the immunity conferred by advancing years.

Fig. 3.—Varicella in male adult showing abundant rash on face and its absence on forearms and hands. Photograph by Dr. J. Howell Griffiths.

General Symptoms.

While moderate pyrexia, nausea, *malaise*, aching in head and limbs occur in varicella, high temperature, sacral pain and vomiting are uncommon.

There is one point of importance, however, in this group—namely, the fact that in small-pox there is a general prostration with muscular flaccidity and tonelessness. The cases of small-pox are very few in which this phenomenon in the stage of the primary fever is not present, and its absence in a suspected case tells strongly against small-pox. The phenomenon is to be noted in all the voluntary muscles. The patient lies like a man prostrate after severe physical exertion, with limbs flaccid and all his muscles relaxed. It is in the facial muscles, however, that the condition is most readily recognized, owing to the fact that in them it is measured by the delicate index of the expression.

In a patient marked by an abundant rash, whose expression is alert, attention keen, and mentalization acute, the diagnosis of small-pox is unlikely, and by a practised observer might be excluded altogether by this observation. A patient suffering from small-pox in a corresponding degree has a dull expressionless facies, with a settled aspect of fatigue and inattention.

The Rash.

It should be observed particularly that no accurate diagnosis can be hoped for without a good light, and a complete examination of the skin. Neglect of these points is a fruitful source of error.

(*a*) *Distribution of the Rash.*

This is a point of cardinal importance. In the revision of the diagnosis of some 7,000 cases examined here during the present epidemic no one criterion has proved more useful or reliable. This is not the place in which fully to discuss the distribution of the eruption of small-pox and to follow out its minutiae. Suffice it to recall its well-known character — namely, the abundance on the face, wrists, and hands, and often on the feet, whereas in comparison it is light upon the trunk.

It is a matter of common knowledge that the site of election for the rash of varicella is upon the trunk, and that the forearms and hands are lightly affected. What is not so generally known is the constancy and reliability of this phenomenon. It should be borne in mind that it is not uncommon in a severe case of varicella, especially in an adult, for the face to show a dense rash, and to be more thickly covered than the back and front of the trunk. But the rash in such a case, as in all cases of varicella, will show a very light relative incidence on forearms and hands, as well as on legs and feet. The more distal the rash is upon the extremities the scantier and smaller it is found to be, and in some cases where the lesions are numbered on the face by hundreds, the skin of the hands is free from any blemish whatever. Such a patient, sitting up in bed, stripped to the waist, with hands crossed, backs outwards, forms a striking picture, and a correct diagnosis might be made readily on inspection, without further examination.

It is not to be thought that if vesicles occur on the palms or soles, varicella is thereby excluded. Such a distribution is met with, though it is not common; and cases in which it occurs are found to conform to the general law of distribution. It is important to bear in mind that it is the *relative*

distribution and density of the rash which are under consideration.

But little importance is to be attached to the distribution on the mucous membranes; lesions on the hard and soft palate are common in varicella.

(b) Character of the Rash.

It is well at once to say what broken reeds to lean upon in diagnosis are the words "shotty" and "umbilicated." It is true that in the small-pox rash the focus of each lesion is placed comparatively deep in the skin, giving rise to a circumscribed sphere of inflamed tissue which on palpation feels not unlike a shot imbedded in the skin; and furthermore that the even distension of the vesicle wall is hampered by fibrous internal ties, and that this is shown on the surface by a flattening or positive dimple. The two phenomena frequently occur, but usually where the diagnosis is very plain from other considerations. Both are completely absent in some cases, and often in those of the most puzzling variety. These signs, therefore, are of little diagnostic use in an obscure case of suspected small-pox. Where they are present they are not needed, and where they are needed they are not present. They are also misleading. In varicella, among other diseases, firm papules are not uncommon, indistinguishable in their shotty character from those of variola. In varicella it is in the coarser skins of adults that they commonly occur. In the same disease a dimple in the *pustule* is common, not in the vesicle, be it observed, and is due to the escape of the contents of the pustule and the consequent falling in of its wall. Yet no sooner are any shotty or umbilicated characters noted of whatever kind, than the case is labelled small-pox accordingly. The expressions are thus pernicious in two ways. Their absence in a case suspected to be small-pox is taken as evidence against that disorder, and their presence in a case otherwise suggestive of varicella is held to negative that disease. The words are fetishes or objects of superstitious worship which help their devotees as much as do most idols, and mislead them far more. They should be treated as such, and discarded. In the differential diagnosis of small-pox there are no more fertile sources of error.

Fig. 4.—Varicella in girl of 12 years showing freedom of wrist and hand from rash. Photograph by Dr. J. Howell Griffiths.

The true distinction between individual lesions of variola and varicella lies in the depth in the skin at which the lesion is placed, and any point which throws light upon this characteristic is of value. As compared with variola the varicella rash is superficial; this is evident in the early formation of the vesicle and its rapid maturation, the early formation and rapid detachment of the scab and in the lightness of the scar. The occasional deep ulcers and scarring which occur in varicella commonly result from adventitious causes such as scratching and the insertion of dirt.

The points by which the superficial nature of the lesions in varicella are most easily recognized are the fineness and thinness of the pellicle covering the vesicle, giving to it with its serous contents the familiar pearly translucency. The shape and outline of the vesicle is characteristic, its position in the skin allowing it often to take on an irregularly oval outline the long axis of which is parallel to the creases of the skin of the part. The situation where these are seen most commonly and clearly are the folds of the axilla and flank; the groins and lumbar region often show similar characteristic lesions. The outline of the vesicle is often crenated and irregular. Owing to the more yielding character of the tissues immediately surrounding it the tension is not so high in a varicella as in a variola vesicle—the outline is less firm and determinate. On palpation the depth of the lesion in the skin may be estimated better by rolling that fold of the skin between the finger and thumb than by pressing it against a bony surface.

Evacuating the contents by a needle is apt to lead to an erroneous conclusion. Complete evacuation occurs in the case of a varicella vesicle, but evacuation equally complete has been noted in several of the cases of variola under consideration in which the lesions when 2 days old have been frankly vesicular.

A point worth notice is the irregular character of the lesions in varicella in a given "window" of the skin. They vary in size remarkably as well as in shape and stage of development. Some may be tense vesicles, others pustular and smaller, others again in various stages of scabbing having run their course, while interspersed are faint and small aborted papules.

In a late stage of either disorder diagnosis rests almost entirely upon the distribution of the scars and such scabs as remain. The diagnosis of small-pox is clinched if the evenly circular disc-like scabs are found, and the brown inspissated remains of pustules in the thick skin of the hands and feet.

In conclusion, the differential diagnosis between the two diseases rests not upon one feature, but upon a careful consideration of all the evidence, care being taken to attach due weight to each point, and especial importance being given to the depth in the skin at which the lesions are placed, and above all, to the distribution of the rash.

[Four coloured plates illustrating Dr. Wanklyn's paper will be found between pp. 44 and 45.]

ANTIVACCINATION PROPAGANDA: THE BANE AND ITS ANTIDOTE.

The Jenner Society.

It would be strange if the name of Jenner, identified as it is with a discovery which has been recognized all over the world as one of the most beneficent in its results, had not been perpetuated in connexion with some public organization established for the purpose of honouring his memory and maintaining his work. And at an early period after the discovery of vaccination a feeling in favour of such a commemoration took shape in the establishment of the Royal Jennerian Society. This body appears, from the account given of it in Baron's *Life of Jenner*, to have originated in a meeting in London on December 3rd, 1802, of some of Jenner's medical friends, when they decided to establish an institution which, "whilst conveying to mankind the benefits of vaccination," should "pay to the author of those benefits its first and best tribute of respect and gratitude." The Society received the patronage and support of the King and Queen, and of a number of other distinguished persons. It was formally inaugurated at a meeting held in January, 1803, at the London Tavern, over which the then Lord Mayor presided, who, we are told by Baron, took his seat for the first time on February 3rd as President of the "Royal Jennerian Institution."

We are further told that the early proceedings of this body were vigorous and prosperous; that thirteen stations (for vaccination) were opened in different parts of the metropolis, in which, during eighteen months, 12,288 inoculations had taken place, and that 19,352 charges of vaccine virus were supplied from the central institution to most parts of the British Empire and to foreign countries.

This institution, thus prosperously started, seems gradually to have got into difficulties. Irregularities, we are told, crept into the proceedings of some of the officers of the Society, the resident inoculator (Dr. Walker) publishing opinions on vaccination, and recommending a practice of it which was contrary to the positive instructions and printed regulations of the Society. A conflict thus arose between Dr. Walker and his supporters on the Council of the Institution on one side, and Jenner, with the majority of that body, on the other. Jenner appears to have carried his point and ejected Walker; but, as he left London and retired to Berkeley, the Institution, or Society—for it is called indifferently by both names, though the former was its official title—lost the benefit of his personal supervision, and dragged on an existence which is stated to have been practically ended by the establishment in 1808 of the National Vaccine Institution, though an attempt appears to have been made to resuscitate it in 1813, when, however, it was finally incorporated with that institution, which had been started by Walker and his friends.

The National Vaccine Institution, the object of which was not only to promote but to carry on the practice of vaccination, appears to have continued in existence until 1853, when the first Act of Parliament was passed rendering the vaccination of children generally compulsory, under a penalty of 20s. for default.

After the collapse of the Royal Jennerian Institution or Society no effort of any kind appears to have been made to connect the name of Jenner with any material embodiment of his work or any organization for promoting it. The value of vaccination was fully recognized by the medical profession, and its utility was so far accepted by the public that the propriety of enforcing it on the infant portion of the population was approved by the Legislature in a succession of Acts which made increasingly effective provision for so doing.

From the earliest days of Jenner's discovery there had been critics who assailed the accuracy of his statements, and opponents who affected to disbelieve the efficacy of his remedy for small-pox. But it cannot be said that the opposition to vaccination exhibited anything like a serious form until after infant vaccination had come to be enforced, so far as it was possible to do so, by legislation, by the Vaccination Act of 1867, as interpreted by the decision of the Court of Queen's Bench in 1870, which instituted a system of penalties that could be almost indefinitely repeated on those who were determined recalcitrants against the vaccination of their children.

Up to this time there had been opposition to vaccination, but it had not been organized. It is needless here to enumerate the various causes which combined to create this organization. It is sufficient to say that it first took formal shape in the year 1880, when the "London Society for the Abolition of Compulsory Vaccination" was established, with the following objects:

1. The abolition of compulsory vaccination.
2. The diffusion of knowledge concerning vaccination.
3. The maintenance of an office in London for the publication of literature relating to vaccination, and as a centre of action and information.

The *Vaccination Inquirer*, which had been started by Mr. W. Tebb, in 1879, was adopted as the organ of the Society, which was fortunate in securing the services of Mr. W. Young, whose enthusiasm in the cause he had been led to advocate was unlimited, and who added to a perfect knowledge of his subject, from his own point of view, an astuteness in controversy which has scarcely been equalled by some of the highly competent pupils who have obtained their knowledge from his writings.

About the same time the support of several members of the House of Commons was secured for the Society, most prominent amongst whom was Mr. Peter Taylor, for many years the member for Leicester, which claims, and with some justification, to be the Mecca of antivaccination.

The success of the campaign against vaccination thus formally opened by the London Antivaccination Society was materially promoted by two favouring conditions. The first was the fact that it appealed to the sympathies of parents, many of whom believed, rightly or wrongly, that they had had unquestionable evidence, in the experience of their own children, of the mischief that vaccination can produce. A cause which appeals to such sympathy as this, and with some justification, is at the outset strongly entrenched.

But the antivaccination agitation would have been able to make but little way without the aid of the material resources which are requisite for promoting a propaganda of any kind. The opponents of vaccination generally must be admitted by any one who knows anything of the history of the movement to have justified the reality of their convictions by the pecuniary sacrifices which they have so often made both in the payment of fines in the law courts and by way of contributions to the funds of their local and central antivaccination societies. But the resources which these contributions supplied would have been quite insufficient to carry on the war with the activity which the London Society has for a good many years exhibited if it had not been for the luck which enabled that body to secure the adhesion of some rich members, one of whom in particular has from time to time munificently contributed to its support. With an income of from £700 to £1,000 per annum it is not surprising that the Antivaccination League has been able to carry on a strong fight, in the press, on public platforms, in the constituencies, and in the Law Courts.

But it did more. Under the influence of Mr. Taylor and others the House of Commons in 1871 appointed a Select Committee to inquire into the operation of the Vaccination Act of 1867. The Committee took a good deal of evidence on the merits of vaccination, for and against, and whilst confirming the belief in the efficacy of vaccination as a protection against small-pox, advised that repeated penalties against vaccination defaulters should be abolished, or at least limited to a single fine of 20s., or to two penalties of any amount. This recommendation was embodied in a Government Bill, which passed the House of Commons, but this particular clause was thrown out by 1 vote in the Lords in a House of 15 members, and was unavoidably dropped. So the infliction of repeated penalties continued, until abolished, on the recommendation of the Royal Commissioners by the Act of 1898.

In 1889 the Government of Lord Salisbury, as represented by Mr. Ritchie, Secretary of State for the Home Department, in response to the increasing agitation against vaccination, which was fomented by the London Antivaccination Society, issued the Royal Commission with which every one is now familiar. This Commission, after dragging on its weary work for the greater part of seven years during which it listened to the alleged evidence against vaccination with which the London Antivaccination Society copiously supplied it, finally reported in 1896.

Meanwhile the Society itself continued to strengthen its position by forming branches in every locality in which an opportunity for doing so offered. These opportunities invariably presented themselves in the person of some obstinate antivaccinist, who had been fined over and over again without any other effect than that of converting him from a quiet disbeliever into a virulent opponent of what he called Jenner's "rite."

Such was the position of matters in the year 1896 when two incidents occurred which brought the vaccination question to a crisis. The first was the issue of the report of the Royal Commissioners on Vaccination, before referred to, and the second was the occurrence of the great epidemic of small-pox at Gloucester. The epidemic attracted the attention of the public not only by its magnitude and by the unusually large mortality of unvaccinated children which it exhibited, but by the dramatic fact that it occurred in the principal town of the county in which Jenner had made his original inquiry, and in which it might have been not unreasonably supposed that faith in the virtue of his discovery would have been least likely to be shaken.

The facts of the epidemic, as they gradually became known and were commented on by the press, in illustration of the value of vaccination and of the folly of neglecting it, as Gloucester had done, naturally put the antivaccinists on their mettle to explain these facts away, and to demonstrate to the citizens of Gloucester and the public generally that the epidemic was not due to the neglect of vaccination, as the press so generally asserted, but to sanitary defects in the state of the city itself.

With the view of enforcing this assumption meetings were held in the city, at which Jenner was denounced as a charlatan by emissaries of the Vaccination Society, who were sent there for the purpose. A copious literature in the shape of handbills, wall posters, and circulars of all kinds was distributed throughout the city and its neighbourhood, and the public both inside Gloucester and outside of it were led to believe that the epidemic was a veritable judgement on the city for its insanitary and even "filthy" condition, and that vaccination had no more to do with the matter than registration had.

The effect of this crusade was not only to grossly libel the city, which curiously enough the local Antivaccination Society had only a few years before formally presented to the Royal Commissioners as a sample of how a healthy and well-ordered town could defy small-pox unaided by vaccination, but it began to exercise a most disastrous effect on the efforts which the local authorities were making to stamp out the epidemic by means of vaccination.

Under the pressure of these circumstances it was decided by some of the citizens of Gloucester, encouraged by the liberal assistance especially of Earl Ducie, the Lord Lieutenant of the county, Sir John Dorington, Bart., member for the Tewkesbury Division, in which Berkeley, the birthplace of Jenner, and the locality in which he had carried on his famous inquiry is situated, and also of others connected officially or otherwise with the district, to form an association for the purpose, as stated by the prospectus issued by them, of "commemorating the name and work of Edward Jenner, M.D., of Berkeley, in the County of Gloucester, and to bring home to the nation, in a time of grave forgetfulness of his great inquiry, the immense benefit he conferred by it upon mankind."

The Earl of Ducie accepted the presidency of the Society; Lord Lister, the then President of the Royal Society, and Sir William Turner, K.C.B., the President of the General Medical Council of the United Kingdom, became Vice-Presidents; and the Dean of Gloucester took the Chairmanship of the Executive Committee. Such was the origin of the Jenner Society in the early part of the year 1896.

Its object at first was purely to meet local needs, in in doing which it was able to undertake a very useful work, as it succeeded in demonstrating to the general satisfaction of the public the untruthfulness of the statements circulated by the Antivaccination Society about the insanitary condition of Gloucester, and thus gave additional emphasis to the lesson which the epidemic taught. By so doing it helped materially to promote the vaccination and revaccination of 35,000 out of the 40,000 inhabitants of that city.

When the epidemic had come to an end and local needs ceased to be pressing it became a question whether the Jenner Society should be wound up or not. But, in view of the increasing interest in and sympathy with its objects, which became apparent from all parts of the country, and of the fact that there was no other organization to meet the activity of the Antivaccination Society which had then blossomed forth as the National Antivaccination League, it was decided to maintain it, and to carry on the work which it had commenced, with as much energy as might be justified by the support afforded by the public. During the six years of its existence the Society has circulated a large mass of literature of various kinds, has procured the insertion of several hundreds of letters in the public journals, in reply to antivaccinist writers, has carried on a large and increasing general correspondence, and has in many ways sought to form public opinion on the subject of vaccination legislation, especially in connexion with the Act of 1898.

In relation to the much debated "Conscience clause" of that Act, the policy of the Society has been to maintain that the advice of the Royal Commissioners, that it was expedient to grant a certain amount of exemption from the requirements of the law in the case of parents who pertinaciously object to the vaccination of their children, was wise in the interests of vaccination itself; but that the exemption should not have been a permanent one; that it should have only been granted for a special period, and should have been required to be renewed at least once, namely, when the child entered the portals of the school. Moreover, the Society contends that this concession should have been safeguarded by the requirement, under similar conditions, of revaccination before the child left the school and by improvements in the administration of vaccination which the Act of 1898 left altogether untouched.

THE IMPERIAL VACCINATION LEAGUE.

It has recently been thought desirable to organize a league in support of vaccination. The Jenner Society has done excellent work for more than six years; but, as its work is carried on at Gloucester, it labours under disadvantages which would not attend an organization having London for its headquarters. It was at first thought that the Vaccination League, started last year by Mr. John T. Carrington and his friends, could be united with the Jenner Society, and the two bodies recast to form a unit which might in time become powerful. Practical difficulties, however, arose as to the basis on which the two societies could be united, and in the end it seemed best that they should for the present work separately, though in friendly alliance one with the other. The Jenner Society remains as a Gloucester memorial to one of the greatest men in the history of practical medicine, and, if carried on upon the lines on which it has hitherto been conducted, it will continue to do good service in defending vaccination against its detractors.

The League, as started last year, has been practically recast in its organization, and strengthened by the adhesion of many eminent persons. It will henceforth be known as "The Imperial Vaccination League." The Duke of Fife is President; Lord Avebury, Treasurer; Mrs. Garrett Anderson, M.D., Honorary Secretary; and Messrs. Robarts, Lubbock, and Co. its bankers.

The list of its Vice-Presidents includes the names of the Archbishop of Canterbury, the Duke of Westminster, the Bishops of London, Stepney, and Rochester, Cardinal Vaughan, the Chief Rabbi, Sir William Broadbent, Mr. Jonathan Hutchinson, Sir Frederick Pollock, Sir Trevor Lawrence, Sir James Crichton-Browne, Mr. Claude J. Montefiore, and the Rev. J. Monro Gibson, D.D.

The Council is not yet complete. It will be composed of eminent medical practitioners and Public Health officers; of large employers of labour, and of other influential persons in direct touch with the classes most prejudiced against vaccination.

The Council will appoint an Executive Committee at its first general meeting. The present executive is provisional.

The League will aim at collecting opinions from those most able to form them, as to what amendments of the Act of 1898 may suitably be urged upon the Government before the end of next year, when the Act will expire. Among the most

important points for consideration will be these: (*a*) Whether revaccination at school age should be made obligatory; (*b*) to what public authority the administration of the vaccination law should be transferred; (*c*) the need for the establishment of thoroughly well-equipped laboratories for the preparation of a supply of glycerinated calf lymph adequate to meet all ordinary demands, and for all establishments for the preparation of lymph being regulated and kept under Government inspection; (*d*) the need for a legal definition of what constitutes "efficient" vaccination, and for all certificates of vaccination to show if the vaccination has been "efficient" or not.

The League will put the opinion arrived at on these points before members of both Houses of Parliament. It will also aim at placing clearly before the public the immense value of vaccination and revaccination as a protection against small-pox, and it will encourage many indirect methods of supporting vaccination.

All this will involve expenditure. The League will consist of members giving at least 5s. a year, and Associates giving not less than half-a-crown a year, but larger donations and subscriptions will be necessary, especially at first.

The Secretary, Dr. E. J. Edwardes, will be glad to receive at the office of the League, 53, Berners Street, W., the names of all who wish to enrol themselves as members or associates of the Imperial Vaccination League. Cheques and postal orders (crossed to Messrs. Robarts, Lubbock and Co.) may also be sent to Dr. E. J. Edwardes, 53, Berners Street, London, W.

THE BACTERIOLOGY OF VACCINIA AND VARIOLA IN ITS THEORETICAL AND PRACTICAL ASPECTS.

The object of the present article is to consider the attempts which have been made to discover a specific organism for variola and vaccinia, and to discuss the questions of the contamination of lymph with extraneous organisms, the action of glycerine upon lymph, and the duration of immunity. The latter considerations will form the basis of some remarks upon practical questions concerning the clinical aspect of vaccination.

1. The Search for a Specific Micro organism.

More than seventy years elapsed after Jenner performed his first inoculation before any important attempt of a scientific character was made to discover the ultimate pathogenic agents which produce variola and vaccinia. There are a few isolated records, such as those of Gluge in 1838, of the discovery in lymph of peculiar minute "corpuscles" or "granules," but they do not seem to have attracted much attention; in fact it was hardly to be expected that their possible importance could have been appreciated at a time when medical science was not in possession of the valuable clue afforded by bacteriology to the interpretation of infective processes. The establishment of the first important step in advance dates from 1868, when Chauveau and Burdon-Sanderson, working independently, proved that, if the solid particles contained in lymph be separated by filtration or precipitation, the solid residue retains the power of producing vaccinia, whilst the filtered liquid has lost it. This discovery laid the foundation for the subsequent bacterial theories. It being recognized that the liquid did not contain the specific virus, the minute bodies, already observed to be present, together with cell débris and other solid constituents, were studied with renewed attention; many of them were shown to be micrococci, and numerous theories soon sprang up which claimed to have discovered in these micro-organisms the specific cause of the disease. The "molecules" of Keber (1868), the "cocci" of Luginbühl (1871), the "microsphaera variolae" of Cohn (1872), and the "tetracoccus vacciniae" of Klebs (1873) may be mentioned as instances of these early discoveries. These theories went on multiplying in number without increasing much in intrinsic value.

The first indication of an improvement in the methods of research was the recognition, on the part of a few of the investigators, that it was possible for micro-organisms to be identified in lymph without their being specific. There is an interesting article, published in 1883,[1] on the micrococci of vaccine found in material obtained from children's arms at the public vaccination institute in Berlin. The director of that institute reports that he obtained the lymph as free from contamination as possible, and gave it to Koch to examine. It was found by culture experiments to contain two, or possibly three, bacteriologically differentiated species of micrococci. Inoculated in animals, after culture to several generations, these organisms only produced quickly developing pustules, which ran a rapid course. Koch also inoculated himself with cultures of his micrococci, the result being the development of pustules, in no way typical of vaccinia, on the second day. The very sensible conclusion drawn from these observations was that, although these organisms appeared to be constantly present in lymph, and certainly produced a reaction when inoculated, they did not represent the specific contagium of vaccinia However, the majority of observers, whilst willing to believe that the bacteria discovered by others might not be specific, were extremely reluctant to adopt the same sceptical attitude towards their own work. Each claimed specificity for the particular organism he had found himself to be constantly present in lymph, and when it became apparent that other investigators had found organisms belonging to other species of bacteria occurring, as they alleged, with equally characteristic frequency, the natural defence put forward in support of any particular theory was that though other organisms might be present they were not specific.

The useful result which came out of the controversies caused by these discrepancies was the general recognition that lymph contains a large variety of extraneous organisms from which the bacterium supposed to be specific must be differentiated. Bacteriologists therefore set themselves the task of devising means which should eliminate the extraneous organisms whilst preserving the specific bacterium intact, in the hope that, having got the latter in pure culture, they might prove experimentally that it retains the power of producing vaccinia. Upon these problems they are still engaged.

In the meantime an endeavour has been made to solve the difficulty in another way. In 1887 Pfeiffer, after demonstrating the presence in lymph of many varieties of cocci, bacilli, and moulds, all of which he considered to be extraneous, urged that the specific parasite was of quite a different kind, and belonged to the genus sporozoa. The organism of this character, which he described, passes through the first stages of its development in the Malpighian layer of the skin. It resembles a coccidium, is unicellular, and round or oval in form. As it develops it becomes encapsuled and then forms spores, which are afterwards set free. These spores are contained in the lymph, and are unaffected by the addition of glycerine, but in that medium are not readily distinguishable in appearance from micrococci. Guarnieri, in 1892, took up this view, and made an elaborate study of the evolution of the supposed parasite called by him "cytoryctes vaccinae," in the cornea of rabbits and guinea-pigs which he had inoculated with vaccine lymph. His conclusions have been received with a good deal of sceptical criticism, and many attempts have been made to prove on histological grounds that the alleged intracellular parasites are nothing more than peculiar forms of cell degeneration and cell secretion. Nevertheless his view is still warmly supported by many writers who, whilst endeavouring to obtain further experimental results from inoculations on the rabbit's cornea, have found it necessary to devote a considerable amount of their attention to answering the histological objections which have been raised.

Thus, at the present day, opinion is divided between the bacterial and the protozoan theory, and we have to consider the nature of the evidence presented in each and discuss its value.

The Bacterial Theory.

Out of the many contributions to the literature from the bacteriological standpoint it is impossible to select any one in which the author can be reasonably considered to have succeeded in completely establishing his case. Moreover, a review of these contributions taken in the chronological order of their publication would present a confusing and heterogeneous mass of detail, with little or no indication of a uniform progression towards the solution of the problem. For these reasons it is best to analyse the work not according

[1] *Deut. med. Woch.*, 1883, p. 500.

to the dates of publication or the names of the authors, who may all be regarded as joint contributors to a still unfinished task, but according to the methods which have been adopted for the elucidation of the subject.

1. We may first mention that attempts have been made by immediate microscopic examination of the lymph itself to find obvious and characteristic indications of a specific fungus. Of these the only one that need be referred to is the endeavour of Buttersack in 1894 to show that dried films of vaccine lymph exhibit threads and granules which are respectively the vegetative part and the spores of the vaccine fungus. In his own words,[2] "in the content and in the environment of the inoculation pustule is regularly to be found a highly characteristic appearance which, corresponding to the clinical course of the pustule, expresses itself in the form of threads or of very fine granules." His illustrations, however, give one the very strong impression that what he describes consists really of nothing more than fibrin threads and various other coagulated material.

2. The belief still keeps recurring that some of the bacteria which are commonly present in lymph and are readily recognized by everybody are, after all, the true explanation of the disease, and that a closer investigation of them by cultural or other methods would show that they are different from the ordinary species they are usually taken for and possess specific properties. Thus, Vaneslow and Czaplewski[3] in 1899 obtained from the pustules and spleen of inoculated calves a coccus which strongly resembled the staphylococcus pyogenes albus in many respects, but when grown on blood serum proved, by the characteristic liquefaction it produced, that it was of a different nature. They called it "staphylococcus quadrigeminus" and endeavoured to demonstrate experimentally its specific properties, a special feature of the experiments being that, before being inoculated into calves, the organism was passed into a hen's egg for a further period of incubation. The result of their work, however, as they subsequently admitted themselves, was a failure. In the same year Sanfelice and Malato[4] record their investigations of an outbreak of small-pox in Cagliari. From the pustules and internal organs of patients who had died of the disease they obtained invariably an organism which, though resembling the staphylococcus pyogenes aureus, differed from that organism in its pathogenic effects when injected intravenously into dogs, and also rendered dogs inoculated with it insusceptible subsequently to vaccinia. While some authors, such as the last named, seem to attach great weight to the constancy of occurrence of their particular organism, others find their clue in a supposed protean multiplicity of forms which their bacterium can assume and apparently explain on that ground the fact that though constantly present and very frequently observed it has hitherto escaped recognition as a single and specific organism. Nakanishi,[5] for example, writes in 1900 of a "bacillus variabilis lymphae vaccinalis," which he describes as a new bacillus of constant occurrence in vaccine pustules. On the whole he finds that his bacillus bears some resemblance morphologically to the bacillus diphtheriae, and he enters into a detailed description, which need not be recapitulated, of the many varieties of form it may assume. It does not produce vesicles in calves.

3. It has naturally occurred to many people that, although the specific bacterium is not demonstrable by the ordinary bacterial stains applied in the usual way, it might make its appearance if we could hit upon an appropriate stain for it, or adapt our ordinary methods of staining so as to meet its peculiarities. In 1892 Klein admitted[6] that, in ordinary stained coverslip preparations from specimens of calf vaccine lymph in its ascertained most effective condition, "there is generally very little to be seen; occasionally a coccus or a diplococcus, and a nucleus of a leucocyte." But if similar coverslip preparations are stained for an extremely long period (twenty-four hours to forty-eight hours in alcoholic gentian violet), they exhibit "unmistakable bacilli distinctly stained." They are cylindrical, 0.4 to 0.8μ long, generally thinner at the ends than in the middle, and often include a spherical or slightly oval clear globule. He says he has found similar bacilli in human vaccine lymph of the eighth day, and in variolous lymph from the vesicles of confluent small-pox collected when the eruption was at the fourth day. In spite of numerous attempts he was not, at the time of writing, able to cultivate these bacilli either in artificial media or in the subcutaneous tissue of the calf. Again, Kent in 1898 declared[7] that he had found the "diplo-bacillus" of vaccinia, and that "cultures containing this organism produce in the calf and in children typical vaccine vesicles." The great difficulty he had to overcome was to find a mode of staining which would demonstrate the organism, but at length he met with success by adopting a complicated modification of the Gram method. The organism was cultivated on a medium of glycerine and egg albumen.

4. The action of glycerine will be discussed in detail later on. Here it need only be mentioned that its power of killing or inhibiting the growth of extraneous organisms, whilst allowing the survival of the specific agent, has been utilized very largely in the endeavour to isolate the micro-organism of vaccine and variola. The number of different bacteria, each at first thought to be typical, which have been isolated by the aid of the bactericidal action of glycerine is so very great that it must suffice to refer to two of them which are fairly typical of the rest. The "bacillus xerosis variclae," says Klein in 1897,[8] "is a non-sporing, non-motile bacillus which was isolated by surface agar plates from an emulsion of small-pox crusts in undiluted glycerine nine months old. Also it was obtained from small pox crusts in emulsion with 50 per cent. of glycerine broth for about 25 days and 33 days respectively." The bacilli corresponded closely in morphology "with the so-called pseudo-diphtheria bacilli, at present considered as a group and called bacillus xerosis." They were, however, not pathogenic when inoculated into calves. The "bacillus albus variolae" is described also by Klein in the same paper. It will survive both pure and 50 per cent. glycerine for a very long time. The individual bacilli are characteristically sticky and present in older growths a variety of involution forms. "Morphologically, therefore, the bacillus albus variolae belongs to the group of diphtheria and pseudo-diptheria (xerosis) bacilli, differing however from them in the circumstance that some of the rods develop into thicker, more deeply stained, masses, behaving indeed like spore forms." With agar cultures of this bacillus Klein inoculated calves, with all possible precautions against vitiating the experiments by contamination with extraneous vaccine material. At first he met with a very encouraging amount of success in the direction of producing vaccinia by means of his cultures, but a year later after repeating his experiments, he writes[9]:— "There can be no question at all that in the case of calves, cultures of the bacillus albus, even when repeatedly subcutaneously injected in what must be considered as enormous amounts (the scrapings of four whole culture tubes), produce no immunity from or antagonism to subsequent successful vaccination."

5. In the belief that the specific organism could not be found because it would not grow on ordinary media, many efforts have been made to find for it a suitable nutritive material. Whilst glycerine is used to inhibit hindrance to its growth, in the nature of extraneous micro-organisms, it is thought that there may be some particular artificial food which will actually stimulate its development. Copeman has used very largely the hen's egg for this purpose, with results of a more positive character than appear to have followed its employment in the hands of Klein. Referring to this work in his Milroy Lectures, delivered some years after his first experiments, Copeman tells us[10] that he inoculated hen's eggs with emulsions of small-pox crusts and then incubated them at 37° C. for a month. Films of the contents then appeared to show "a pure culture of one organism only, namely, a bacillus which morphologically was not to be distinguished from the bacillus which I have previously described as to be found in early vaccine lymph." Inoculating egg cultures on the calf, "I obtained a strain of lymph which after being passed through a series of calves was successfully employed for the vaccination of children. The calves were all subsequently vaccinated with negative results." Klein[11] expressed

[2] *Arb. aus dem k. Gesundheitsamte*, Bd. ix, 1894, p. 96.
[3] *Centralbl. f. Bakt.*, Bd. xxv, p. 141 and p. 546.
[4] *Centralbl. f. Bakt.*, Bd. xxv, p. 641.
[5] *Centralbl. f. Bakt.*, Bd. xxix, p. 641.
[6] Supplement to Report of Local Government Board, 1892-3, p. 391
[7] *Lancet*, May 21st, 1898.
[8] Supplement to Report of Local Government Board, 1896-7, p. 267.
[9] Supplement to Report of Local Government Board, 1897-8, p. 342.
[10] BRITISH MEDICAL JOURNAL, May, 1898, p. 1248.
[11] Supplement to Report of Local Government Board, 1896-7, p. 267.

an interest in these results, and examined the contents of two series of eggs furnished by Dr. Copeman after inoculation with vaccine and variolous material respectively by his method. As, however, he failed to get positive results with them, Klein repeated Copeman's experiments in their entirety for himself. He met with no success, as the eggs after incubation either furnished only ordinary staphylococci and B. mesentericus or were sterile.

6. Lastly, the final and crucial experimental test to which every reputed "vaccine organism" must submit is the production of vaccinia. Mention has already been made of a certain measure of success in this respect which some experimenters claim; but it is only fair to add that there are many other bacterial theories, here unnoticed, to be found in the literature, some of which seek their justification on this ground.

The Protozoan Theory.

As pointed out above, the advocate of this type of theory finds it his first duty to prove that his "parasites" really are living bodies, and not the products of degenerative changes in the epithelial cells. In order to understand the present position which the theory occupies, we must therefore first consider some of the more recent criticisms which have been directed against it, and to which the believers in the theory think they can make a satisfactory reply. Three of these criticisms may be selected as being each representative of some features of special interest. Salmon[12] shows, from an elaborate comparison of the reactions of various stains upon the minute details of epithelial cells and white blood corpuscles, that Guarnieri's "bodies" correspond exactly in their affinities for dyes to the constituents of polynuclear leucocytes. He therefore regards them, confirming his view by animal experiments on the cornea, as aggregated masses of chromatin, derived from the broken-down leucocytes which have invaded the tissue, and absorbed by the epithelial cells. In this way he accounts for the fact that the staining affinities of these bodies differ from those either of the protoplasm, nucleus, or nucleolus of the epithelial cells. He concludes his criticism with the words, "the examination of vaccine granules brings us back to a simple problem of cellular reaction, of a special, indeed, if not of a specific kind, to a particular chapter of the theory of inflammation." Hückel[13] has endeavoured to check the results obtained by Pfeiffer and Guarnieri by following in the lines of Guarnieri's work, and examining for himself the effects produced by systematic inoculations of the corneas of rabbits with vaccine material. The result of his work is a very exhaustive treatise, containing an elaborate classification of the appearances met with in vaccinated areas, together with copious illustrations of them. All his observations tend to show that the "organisms" of Guarnieri are not really parasites, but arise from a special process of transformation of the epithelial cytoplasm due to the specific stimulus of the vaccine virus. He therefore arrives at the opinion that "the peculiar formations thus arising, the manifold appearances of which must be conditioned by changing, and as yet unknown, structural relationships of the cytoplasm, appear therefore as the direct consequence of the latter, and not as the causative parasitic protozoa of vaccine which they have been declared to be." But perhaps the most thorough and painstaking study of the minute histology of vaccinia is that which was carried out by Mann.[14] It has the particular advantage, compared with records of such very artificial processes as those occurring in the rabbit's cornea, of describing the lesion as it actually occurs in calves subjected to ordinary vaccination, and of tracing out the lesion in the course of its evolution from the first to the hundred and forty-fourth hour. His work is too extensive and his arguments are based on too many minute details to admit of a brief summary. We must therefore content ourselves with stating that his general conclusion is that Guarnieri's bodies are not parasites, and with quoting a few of his observations of special interest on more minute points. Some of the appearances thought to be parasites he attributes to "a distinct eosinophilous element which is of nucleolar origin, and usually placed at the poles of the nucleus." Again, there is "secondly a basophilous structure, cytoplasmic in origin, which is usually seen best in those cells in which the nuclei stain deeply in polychromemethylene-blue-tannin preparations. There is also a third body which is neither of nucleolar nor cytoplasmic origin, but which consists of matter secreted by the nucleus. This material may present a crescentic appearance." In dealing with the question whether, after rejecting Guarnieri's bodies, it is possible to demonstrate anything else that may with more probability indicate a specific organism, he says: "With all reserve, attention may be drawn to certain appearances found during the second and third day after vaccination in the cell-plasm of the epithelial cells." He then goes on to point out that, after staining with Möller's method for spores, there are to be found "a number of exceedingly small granules, varying from 0.2 to 0 25 μ in diameter....These elements are most distinct close to the perinuclear sac, because there the thinness of the cell is more marked. The granules are usually arranged in pairs; they lie between the epithelial fibrils, and are very numerous....Are these bodies micrococci, or are they merely a granular precipitate?"

In endeavouring now to obtain a fair representation of the arguments which the upholders of the protozoan theory bring forward in refutation of these objections, and to appreciate the additional positive evidence they have to offer in support of their view, we have the advantage of a recent article published by Wasielewski,[15] a pupil of Pfeiffer's, which not only gives us a very comprehensive and masterly survey of the whole ground, but compares very favourably with much of the literature on both sides of the question in its freedom from bias and its anxiety to avoid the over-hasty formulation of a positive and dogmatic conclusion.

Whilst, therefore, it ought to be mentioned that several writers who are better known in this country—such as Ruffer, Plimmer, and Jackson Clarke, are followers of Guarnieri's views, and that Clarke goes so far as to declare that,[16] "according to the writer's experience, every parasitic form which occurs in vaccinia occurs also in cancer," it will be more profitable to take Wasielewski as the representative authority on the subject. Wasielewski classifies arguments against the parasitic theory which are based on the ground that the bodies observed are degeneration products under three headings, according as the alleged degenerations are (1) non-specific degenerations of epithelial cells; (2) specific degeneration products of leucocytes; or (3) specific degeneration products of the protoplasm of epithelial cells.

Dealing with (1), Wasielewski criticizes in detail the work of Mann, Hückel, and others, the gist of his argument being that either what those observers describe as degeneration products, "nuclear secretions," and the like really are such, and in that case are not comparable to the true parasites which are also present, or, in other cases, that what are described as "degenerations" really are parasites, and that the assertion of their inanimate nature is arbitrary, and not justified by any positive evidence. As regards (2), the leucocyte explanation of Salmon, Wasielewski says that he has already shown in 1898 "that the similarity of staining reaction between vaccine bodies and leucocyte nuclei, which is the fundamental argument on which Salmon's work is based, is not constant, and, if we choose other methods of staining, is no longer forthcoming." (3) In endeavouring to refute the theory of specific degeneration of cell protoplasm resulting from a reaction to the vaccine stimulus, Wasielewski criticizes in detail the work of Hückel. As against the hypothesis (which is the logical deduction from Hückel's position) that there must in the vaccine poison be a chemical factor which is capable of introducing into normal cytoplasm a modification which in its staining properties approximates to nuclear material, he urges that there is no analogy to be found either in normal or in pathological histology which would corroborate such a view. On the contrary, he finds in the long accepted view that malarial parasites were degeneration products of red blood corpuscles, an analogy which suggests that, as in that case so in the case of vaccinia, the so-called degeneration forms will ultimately come to be universally recognized as living parasites.

Analysing the claims of the protozoan view, Wasielewski

[12] *Ann. de l'Inst. Past.*, 1897, t xi, No. 4.
[13] *Ziegler's Beitr. Supplement*, H. ii, 1898. Die Vaccinekörperchen.
[14] Supp. to Rep. of Loc. Govt. Board, 1898-9; *On the Histology of Vaccinia*, part 2, Histology, p. 508.
[15] *Zeitsch. f. Hyg.*, Bd. xxxviii, 1901, p. 212; *Beiträge zur Kenntniss des Vaccinecregers.*
[16] *Path. Soc. Trans.*, 1895, p, 192.

describes them as resting upon the following main contentions: (1) In their characteristic form the parasites appear exclusively in vaccinia and variola; (2) they appear constantly after vaccination of the cornea; (3) when the inoculation is performed with material other than vaccine they are not forthcoming; (4) they have specific properties; (5) they exercise a special influence on the growth and modification of epithelium. He then proceeds to consider how far these claims can be borne out by the results of his own investigations and a comparison of the work of others. A point on which he lays some little stress in his own work is that vaccine material, after being transmitted through more than forty rabbits' corneas in succession, was shown to produce vaccinia in the calf, the animal afterwards proving insusceptible to ordinary vaccination. Children were also successfully vaccinated with material of similar origin.

His main conclusions are as follows:

1. "Vaccine bodies" are exclusively characteristic of vaccinia and variola, being absent both from normal skin and in other lesions; the so-called vaccine bacteria are merely saprophytes of no etiological significance, as is proved by the activity of bacteria-free lymph.

2. The "vaccine bodies" are to be found invariably in rabbits' corneas properly inoculated with active lymph.

3. These same bodies do not make their appearance in rabbits' corneas under any other circumstances.

4. They are not leucocytes or disintegration products of leucocytes.

5 Their supposed origin from the nuclei of epithelial cells is disproved by (*a*) their making their appearance in perfectly normal cells, (*b*) their presence in cells during mitotic division, and (*c*) the position of the smallest "vaccine bodies" at the periphery of the cells far away from the nucleus.

6. Their origin from cell protoplasm as the result of a specifically toxic action of the vaccine stimulus is capable neither of demonstration nor of exact refutation, but is extremely improbable because (*a*) the exciting cause of vaccinia cannot pass through a filter, and hence there is no reason to suppose that it is of exceptionally small dimensions; (*b*) the vaccine agent can make its appearance in normal cells engaged in mitosis, the protoplasm of which presents no appearance of undergoing degeneration through the action of a toxic agent; (*c*) to such a postulated toxic agent no parallel can be found; (*d*) the rapidity of the characteristic changes which the tissues undergo in vaccinia is not suggestive of a degenerative process; (*e*) the occurrence of the characteristic cell-inclusions is not comparable to any known degenerative process; (*f*) the inactive filtrate of vaccine lymph produces no toxic action in the epithelium.

7. The size, shape, structure, and mode of division and distribution of the "vaccine bodies" are all in favour of their being cell parasites.

8. The fact that vaccine can retain its activity after being transmitted for forty-six generations through the rabbit's cornea shows that the vaccine agent can undergo active proliferation in that site.

9. Since at the site of inoculation (in such experiments as the last mentioned) it is not possible, either microscopically or bacteriologically, to demonstrate the presence of micro-organisms other than the "vaccine bodies;" and whereas these latter constantly occur, even to the forty-eighth generation, "the assumption of Guarnieri that the vaccine bodies are actually the exciting cause of vaccinia must be regarded as highly probable."

There is one other recent contributor to the protozoan side of the question whose work is of sufficient importance to require mentioning. Early in 1901 Funck[17] described the results of two years' experimental work on the subject. In arriving at his conclusion that vaccinia is a protozoan infection, he relies very considerably on the bactericidal action of glycerine, declaring that he has bacteriologically examined twenty samples of lymph from different sources which had been kept for three months in glycerine, and found them all sterile, yet at the end of that time they were all effective in producing "absolutely characteristic pustules." He calls the specific protozoon the "sporidium vaccinale," and says that previous descriptions by other writers of vaccine parasites are inaccurate, because too much reliance has been placed on the appearances met with in histological sections, which, owing to the necessary fixing and hardening processes, distort the true appearance. He recommends us to examine the organism in the fresh condition, adding a trace of glycerinated lymph to a drop of bouillon on a coverslip, and observing it by the hanging-drop method in a moist chamber. The spore-bearing cysts, he finds, are of sufficiently large size to be easily recognized under a low power of the microscope. Utilizing this fact, he was enabled, with practice, to pick them out of the fluid containing them with the aid of the flattened end of a platinum needle. The spores thus collected were placed in bouillon, and with this material calves were inoculated, the result being typical vaccinia, confirmed by their subsequent immunity against ordinary vaccination. He has also had the opportunity of examining the contents of pustules in several cases of typical variola, and has found similar elements to those he describes as characteristic of vaccine lymph. On May 23rd he published in the same journal a further communication on the subject, in which he defends himself against certain criticisms, and in particular against the allegation that, because certain of his "morula" forms stain with Soudan red—the well-known stain for fat—they are nothing more than products of cell degeneration, or such contents as are normally found in the cells of the skin glands.

Before leaving this part of the subject a word ought to be said about the "granular amoeboid bodies" which are sometimes supposed to be present in the blood in vaccinia and variola, and which the protozoan theorists are apt to rely upon as confirmatory of their view. Reed,[18] who has extensively investigated this question, has frequently found them, confirming, in this respect, the observations of Pfeiffer. He has also, however, found very similar bodies in normal blood. Billings,[19] working subsequently, made periodical examinations of the blood of 14 persons who were successfully vaccinated, but was unable to confirm the results of the former investigators. It is clear that the supposed presence of demonstrably specific "amoeboid" bodies in the blood is very far from being sufficiently well authenticated to be taken as evidence of any value.

Comments.

We have endeavoured to present in an appreciative and impartial light the heterogeneous and irreconcilable theories upon the etiology of variola and vaccinia which are current at the present day. In undertaking the task of criticism it is extremely difficult, if not impossible, to deal with these various views in a manner which is likely to be accepted as fair or adequate by all the partisans of particular interests. We may begin by pointing out that however sincere the faith of any particular worker on the subject that his views will ultimately gain general recognition, and however large be the immediate circle of his present supporters, the etiology of small-pox is still, in the practically unanimous opinion of the entire medical profession, an unsolved problem. The work which has been done on the subject is recognized to be of more or less value as contributory evidence towards the solution, but none of it has attained the pre-eminence of a substantial ground from which to arrogate for itself the right of authoritatively pronouncing a verdict. It is therefore a matter for regret that, with a few noteworthy exceptions, those who have conducted researches in this field give utterance to dogmatic conclusions and sweeping generalities which are far from being justified by the very limited and inadequate premisses on which their deductions are based. Fortunately the terminology of uninteresting mistakes soon passes into oblivion, but if only the whole category of phantom organisms were to be mustered in review which once boasted "variolae" or "vacciniae" for their terminal appellation, what a significant commentary they would silently present upon the history of human error!

It is to some extent a pardonable anxiety for fame which leads the investigator to magnify a few interesting but imperfectly corroborated experiments into a great discovery which would create him the Jenner of modern pathology. But the serious aspect of such ill-advised ambition is that it shakes the confidence of the medical profession; medical men

[17] *Deut. med. Woch.*, February 28th, 1901, p. 130.

[18] *Jour. of Exp. Med.*, September, 1897.

[19] *New York Med. News*, 1898, p. 301.

not only cease to be impressed by these over-pretentious discoveries, but are provoked by them into an habitual attitude of sceptical distrust towards any pronouncement upon medical science which bacteriology is likely to offer; and in the general interests of pathology, which is a science not only rapidly extending its sphere, but deserving to be seriously recognized as capable of substantially appreciating the value of evidence, it is both undesirable and mischievous to indulge in the rash publication of unreliable results which cannot fail to shake the confidence of the medical practitioner in the theoretical validity and the practical efficacy of the science as a whole.

That a continuation of research is justifiable in quest of a specific parasite of some sort or other, there can be no reasonable doubt. The light which has been thrown upon the causation of infectious diseases during the last twenty years gives us every reason to hope that at some future period the specific organism of small-pox will be known as familiarly as is that of tuberculosis.

To come to the bacterial theories, it must be remembered that the recognition of a bacterium largely depends, in the present state of our knowledge, upon its capacity for taking the stain of certain aniline dyes. Now we know that though we have special methods which will stain the spores of ordinary bacilli and other special methods which will demonstrate the presence of a capsule in various bacteria, both spores and capsules exhibit a remarkable reluctance to react to a stain of any sort, and, in ordinary routine methods of demonstrating the presence of bacteria, are left unstained. We have also reason to believe that some non-sporing bacteria, such as the tubercle bacillus, may often stain very imperfectly, and sometimes not at all, even though, as proved by guinea-pig inoculations, they still retain their vitality. It is, therefore, perfectly rational to suppose that there may be a bacterium of small-pox, although we may not have hit upon any staining method which will make it visible; and it is very likely, as Klein long ago pointed out, that if such a bacterium exists it will, in ordinary active lymph, exist in the form of spores, or with some other protective modification of its structure, which renders it difficult to stain.

If we consider the special cultural methods which have been devised to meet the supposed requirements of the specific organism, we must recognize that the once reputed value of the hen's egg seems now to be pretty generally recognized as having been over estimated. The arguments based on the eliminative action of glycerine must be interpreted with caution. The opponents of the bacterial theory say that because very pure glycerinated lymph which does not produce a growth on ordinary culture media is still active, the efficient cause of vaccinia cannot be a bacterium. On the other hand, some bacteriologists find that apparently sterile glycerinated lymph will produce a growth, which they hope to prove specific, if it is only incubated for a sufficiently lengthy period; others declare that it is the medium which is at fault and that if the appropriate medium could be found a bacterial growth would, in spite of the glycerine, promptly ensue. The facts appear to be as follows. Some organisms, apart from spore formation, are very much more resistant to the action of glycerine than others; spores are particularly resistant and very frequently survive indefinitely. Again, the merely inhibitory action of glycerine must be carefully distinguished from the positively bactericidal. Further, the glycerine itself, though reputedly pure and sterilized, may contain highly resistant living organisms. Two consequences follow from these considerations. We must not too hastily assume that the glycerine has killed all the bacteria present and we must attach considerable importance to the method in which we make our cultures. If we simply smear our glycerinated lymph over a prepared agar plate or slant, of course the glycerine is still in contact with any living organisms present and is very likely to continue to inhibit their growth. If we prepare our plate by inoculating melted agar tubes and then pouring them, we certainly get some dissipation of the glycerine from the immediate environment of possible organisms; but, even then, the agar sets in a few moments and we cannot suppose that in that short space of time the glycerine, which we know may take several weeks in order to penetrate an organism so thoroughly as to kill it, has made its exit so completely and effectually as to permit the active growth of an organism which has been inhibited without being killed. Evidence from broth cultures, which allow of the continuous diffusion and dilution of the glycerine, is a much more satisfactory proof that the material is sterile, but is much less frequently forthcoming.

And, if caution is necessary in interpreting the action of glycerine, it must be redoubled when we come to consider the arguments based on successful inoculation experiments. We need refer only to such inoculations as actually have been known to produce fully-verified vaccinia. There are several points which we must bear in mind when considering these experiments. There is the danger, in the first place, that, in spite of every precaution honestly adopted and conscientiously carried out, there may have been some accidental contamination at one or other stage of the proceedings with ordinary vaccine material. It has been found experimentally that vaccine material, even when diluted as largely as 1 in 2,000, will—of course by no means invariably, but in a small percentage of insertions—produce true vaccinia. Bearing this in mind, we can understand that if a culture tube or hen's egg is inoculated with lymph, and the resultant growth or a portion thereof is taken from the surface of the agar or the contents of the egg and then directly inoculated into a calf, the material so conveyed may, together with the organisms upon which the attention of the experimenter is entirely concentrated, contain enough of the original material, quite independently of those organisms, to produce vaccinia; and this may still occasionally be the case when the inoculation is made from subcultures to which has been transferred an appreciable portion of the original material; and, it ought perhaps to be added, the theoretical possibility still remains that the true agent, though unrecognizable, may multiply side by side with a recognized bacterium, and would then naturally be inoculated unobserved along with the latter and obvious organism, to which specificity would erroneously be ascribed.

Coming to the protozoan theories, it is obvious that, although there is nothing *a priori* impossible in those which are properly enunciated, their advocates have a more difficult task before them than the bacteriologists. After all, in these very doubtful questions, there is a certain amount of presumptive evidence in favour of the theory which has to its record the greater number of successes in the past. During the last 30 years the successes of bacteriology in elucidating the etiology of infectious diseases have been most brilliant, and although it is true that highly important discoveries have also been made concerning the pathogenic properties of certain protozoa, the analogy of the relation between known pathogenic protozoa and their known specific effects as compared with the relation between a hypothetical protozoon of variola and the known specific symptoms of that disease is very slight indeed when contrasted with the analogy of the relation between known pathogenic bacteria and their known specific effects as compared with the relation between a hypothetical bacterium of variola and the specific symptoms attributable to it. In other words, small-pox is much more like a bacteria-caused disease than a disease caused by protozoa. But, whilst pointing out this difficulty in the way of the protozoan theory, we by no means commit ourselves to the view, which would be mere rashness considering the obscurity of the entire subject, that the accuracy of the bacterial hypothesis is a foregone conclusion. The question is still open, and any evidence brought forward either by the one theory or the other which betrays sufficient observance of the elementary rules of logic is fully entitled to thorough consideration, and is not likely to pass unnoticed through lack of general appreciation.

But the protozoan advocates should remember, in their own interests, that whatever be the merits of their case it is a dangerous procedure to press into their service evidence which is of a dubious nature, or to make too light of those objections which, whether valid in this particular application or not, are deductions from fundamental principles of wide pathological significance. The histological appearances of the epithelial cells in vaccinia are, as is generally admitted, highly interesting and peculiar. But the appearances which cells may present in various other inflammatory, proliferative or degenerative processes are extremely varied and complex; so that it is most hazardous for any morbid histologist, however wide his ex-

perience, to declare roundly that because he has never seen anything quite like a certain histological detail in a cell before, that appearance must therefore be due to the presence of an extraneous organism. There is a conspicuous tendency. in some of the theories referred to, to resort to this type of argument. Again, an appeal is often made to the confirmatory evidence to be derived from the supposed presence of parasites in the tissues of malignant disease. The question of cancer parasites does not concern us here; but whether their existence be probable or not they have at all events not been demonstrated in such a way as to gain universal recognition, and it is therefore both beside the point and positively damaging to introduce such incompletely authenticated evidence in support of a particular theory of small-pox.

It is also noticeable that the protozoan theorists seem to lose more than they gain by laying too much emphasis on the weakness of the rival bacteriological theory. It may be admitted that the bacteriological theory is, as yet, unsatisfactory, and that it is legitimate and justifiable criticism to urge that, since no bacteriologist has succeeded in cultivating the specific organism, the way is still open for an alternative explanation. But it is injudicious and a sign of weakness to trespass beyond the limits of legitimate controversy by implying that, because the bacteriologists have failed, their cause is hopeless, and that this very hopelessness is positive evidence in favour of the protozoan view. Moreover, this method of arguing ignores the fact that many reputedly sterile lymphs are not really so, and also disregards the still more important point that no one has the least right to assume that the bacteriologist has already reached the ultimate limits of choice in the selection of suitable culture media. There is too much of this tendency to a style of argument which is merely a particular modification of the *ad hominem* fallacy, and reminds one of the popular notion that, in legal circles, when a barrister finds that his case is weak he resorts to the feeble expedient of abusing the opposing counsel.

Upon the confirmatory experimental evidence which Wasielewski and Funck bring forward as regards the production of vaccinia by their organisms there is not much to be said. Suppose we inoculate the vaccine virus into the rabbit's cornea, and then after a time remove certain material at the site of the lesion; with this material we inoculate a second rabbit's cornea, and continue the process forty or more times in succession; and we may suppose further that the material from the last rabbit's cornea can be proved to retain active vaccine virus. Then we have indeed positive evidence that the material has been transplanted from animal to animal without losing its specificity; and we may or may not regard this fact as evidence to show that the specific material has been actively propagated in that medium. But at all events we have no proof which will bear the test of a moment's serious scrutiny to the effect that, because all these rabbits' corneas present similar intracellular peculiarities supposed to be protozoa, these hypothetical bodies are the active agent in the material finally used for inoculation.

It is hardly necessary to say that Funck's method of picking out of lymph what he believes to be specific spore-containing cysts, and then producing vaccinia with the material so removed, is open to the obvious objection that the active agent may be in no way related to these "spores" or "cysts," but simply have been removed, unnoticed, along with them.

In concluding these comments it may be repeated that the adverse criticisms which have been offered are not intended as a disparagement of any serious effort which has been made to elucidate the subject, nor are they meant to imply that the quest for a specific organism is hopeless. They have been put forward in the belief that a clearer and more impartial appreciation of the value of evidence would facilitate the labours of those who are working at the problem and expedite the progress to that ultimate success which, it may confidently be expected, will some day be attained.

2. Extraneous Organisms in Lymph.

The search for a specific vaccine organism, although it has not yet been successful, has at all events been of service in emphasizing the interesting and practically important fact that vaccine lymph in its natural state is almost always contaminated with a considerable variety of extraneous micro-organisms. As soon as attention was directed to this fact, its clinical significance became apparent, since it was obvious that no lymph was fit to be used for human vaccination so long as it was contaminated with bacteria which might be productive of injurious effects. Hence systematic investigations have been carried out in most of the leading vaccination institutes with a view to determining the varieties, number, and possible pathogenic properties of the organisms actually present or likely to occur in the lymph which was being prepared for clinical use. In considering some of the typical results which these researches have furnished, it is desirable to take statistics from as widely different sources as possible in order to avoid the danger of generalizing too freely from observations confined to a particular locality or made by a partfcular person.

German Investigations.

Deeleman[20] in 1898 examined bacteriologically 39 samples of lymph sent to him from the vaccine institutes of different German towns. The number of organisms per cubic centimetre in different samples varied from 1,550 to 8,337,766; the samples, however, were not strictly comparable as regards quantity of contamination, owing to their being of different ages, the older, from a longer exposure to the action of glycerine, being naturally less impure. The varieties of bacilli identified were very numerous. Species commonly met with in faeces, earth, and water were frequently detected. Organisms of the proteus and the coli types were found, and also, somewhat frequently, varieties of the fluorescens class. A short, thick bacillus, which liquefied gelatine and formed on agar colonies resembling those of staphylococcus albus, is also noted. Of the subtilis class, B. mesentericus was the commonest representative, whilst B. subtilis itself was also present not infrequently. In several samples were found bacilli of the diphtheria type, which, however, proved not to be pathogenic for animals. The cocci were mainly staphylococci, the yellow variety occurring in 74.3 per cent. of the cases, the white in 60 per cent., and the citron-yellow in 12 per cent. In one case was found a streptococcus, proved not to be pathogenic, and identified as the streptococcus brevis. There were also sundry sarcinae, yeasts, and moulds. Of the staphylococci a few specimens, found in samples of fresh lymph only, proved pathogenic for animals; but Deeleman points out that this fact does not prove that they would necessarily be pathogenic for man, and is inclined to think that this would not have been the case, since it has been found that children have been inoculated without any ill-effect with fresh lymph which has afterwards been shown to contain staphylococci fatal to animals.

Pfuhl,[21] writing in 1898 of his experience in the official station in Hanover, says: "Strictly germ-free fresh lymph will, in my opinion, always belong to the region of Utopia." As the result of his own experiments he found that every sample of lymph contained bacteria in greater or smaller numbers and frequently yeasts and moulds as well. Cocci of some sort were present in every sample, the total number of varieties comprising two kinds of diplococci, five of staphylococci (one white, two yellow, one grey, and one red), and one kind of streptococcus of doubtful nature and not pathogenic. Five kinds of bacilli were noted, a short, immotile, greyish-yellow bacillus being found in three-fourths of the samples and hay bacilli and B. fluorescens liquefaciens making their appearance occasionally. Animal experiments with the organisms obtained gave very few pathological results. Two mice died with evidence of disease as the result of inoculation and had apparently succumbed to a mixed infection, through the summation of the effects of the various bacteria present. Pfuhl lays some stress on the fact that no single species of organism when inoculated in pure culture proved capable of killing a mouse.

Upon the question as to the clinical effects which extraneous organisms present in lymph are found to produce upon the course of vaccinia, a very definite attitude was adopted by the German Commission which published its results in 1896. Their conclusions[22] are well worth quoting, although some people may not feel prepared to agree with them without a little qualification. They found on bacteriological ex

[20] *Arb. aus dem k. Gesundheitsamte*, 1898, Bd. xiv, s. 33.
[21] *Zeitschr. f. Hyg.*, Bd. xxx, 1898, p. 251.
[22] *Centralbl. f. Bakt.*, Bd. xx, 1896 p. 829.

amination of the inflamed tissue surrounding the site of inoculation in children's arms, that nine-tenths of all the cases of intense reaction proved bacteriologically sterile or almost sterile, whereas pustules which were accompanied by no such reaction were found to contain large numbers of bacteria. As against the alleged connexion between extraneous bacteria in lymph and inflammatory reactions they urged the following objections: (1) The number of cases of excessive reaction produced by a particular lymph is never more than a small percentage of the total number of vaccinations for which that lymph has been used; (2) the presence in lymph of active organisms capable of producing suppuration in man has only been demonstrated in exceptional and isolated instances; (3) the majority of bacteria usually found in lymph are harmless saprophytes or the ordinary skin parasites, which do not make their way into the intact pustule before the seventh day; (4) a considerable diminution or a complete elimination of the extraneous organisms in lymph is not followed by a noticeable decrease in the frequency or intensity of the inflammatory reactions; (5) there is no causal relationship to be found on bacteriological examination between the presence or absence of pyogenic organisms in the pustule and the presence or intensity of the inflammatory reaction; (6) in cases of pseudo-erysipelatous or phlegmonous manifestations, specific exciting agents (staphylococci and streptococci) are not found.

They conclude that the production of a reaction in the surrounding tissue is an integral part of the process of vaccinia and that the preparation of an effective lymph which does not cause such is an impossibility. Excessive reactions they believe are generally due to (*a*) the idiosyncrasy of the person inoculated, (*b*) too great concentration of the lymph, or (*c*) a faulty technique, for example, making the insertions too long or too close together. True erysipelatous or other inflammatory reactions attributable to specific bacteria they consider to be due to accidental lesions and secondary infection of the wound.

English Investigations.

One of the most interesting series of observations made in this country is that recorded by Fremlin.[23] He examined bacteriologically vaccine material collected from 500 calves at the Government Vaccine Institute during 1899 and the early months of 1900. Cultures were made of fresh lymph pulp after trituration and admixture with glycerine. A loopful of the resulting emulsion was taken and agar plates were prepared from it; the loopful corresponding approximately to one-seventh of the amount of glycerinated lymph contained in a capillary tube.

The following are his results expressed in tabular form:

Organisms Found in the 500 Specimens of Lymph Examined.

		No. of Times Found.
1.	Staphylococcus Pyogenes Aureus ...	500
2.	Staphylococcus Pyogenes Albus ...	484
3.	Bacillus (not named)	370
4.	Staphylococcus Cereus Albus	300
5.	Streptothrix Alba	50
6.	Hay bacilli	31
7.	Sarcina Lutea	22
8.	Staphylococcus Pyogenes Citreus ...	7
9.	Staphylococcus Cereus Flavus	6
10.	Penicilium Glaucum	4
11.	Proteus Vulgaris	2
12.	B. Fluorescens Liquefaciens	1

With regard to the unnamed bacillus found third in order of frequency amongst the above mentioned organisms, Fremlin remarks that it had not been observed in plate cultivations made before February, 1899, but had almost constantly appeared since, although the calves had been inoculated with lymph obtained from a variety of sources. As Fremlin finds in this organism characteristics suggestive of Nakanishi's "bacillus variabilis lymphae vaccinalis," to which allusion has already been made, and which is supposed by the latter authority to be specific, it is of interest to mention some of the details of Fremlin's description. It is a non-motile bacillus, 2 to 4 μ long, and varies in form, sometimes being rod-shaped and sometimes pyriform. It does not stain by Gram's method. It is a highly resistant organism, as it will survive exposure to the action of glycerine for seven weeks. It does not grow at 20° C., but grows well at 37°, producing colonies which are duller and more brownish or granular in appearance than those of staphylococci. It grows well on most ordinary media, but only with a scanty, pale ochre growth on potato. It does not curd milk or ferment sugar.

Of the hay bacilli Fremlin says: "I have noted the following species belonging to this group—B. subtilis, B. mesentericus vulgatus, B. mesentericus fuscus, and B. mesentericus ruber. None of the above bacilli are pathogenic, and with care in collecting and storing lymph, their number can be reduced to a minimum."

Another feature which adds considerably to the practical value of Fremlin's work is that he has supplemented his investigations with an examination of the bacteria occurring in the calf stables and in the skin of the calf at sites where they might contaminate the vesicles. Testing the skin of the calf in the vaccination area when ready prepared for the performance of the operation, he found that no bacterial growth could be obtained by culture. "Cultures were also taken from the surface of the skin of a calf between the lines of the vesicles at a time when the vesicles were matured, and after the vaccinated area of the calf had been thoroughly cleansed in readiness for collection. From the inoculated surface agar growth of S. pyogenes aureus and albus was obtained." Bacteriological examination of hay obtained from the calf stables yielded a pure culture of B. subtilis. Straw from the loft was shown to contain B. mesentericus and S. pyogenes aureus, and straw taken from the calf stalls produced cultures of B. subtilis, S. pyogenes aureus, and a mould. "Calf faeces were also examined, but no organisms were found corresponding to those obtained from lymph pulp." All work in this direction is interesting, because it is important to know not only what organisms are actually present in fresh lymph, but where they come from.

As regards the number of organisms to be found in freshly prepared lymph, where the glycerine was merely a diluent and had not had time to act bactericidally, Fremlin found that the average, as estimated by the growth of colonies on agar plates, was 123 000 per loopful. In cases where the number of colonies is greatly in excess of this, he considers that "there is suggestion that the lymph is not of first-class quality." He thinks that such excessive impurity is probably due to the derivation of the lymph from imperfect, crusted vesicles, containing dead epithelium and débris, and points out that the large number of organisms harboured by such material would necessarily contaminate the lymph as it was being drawn.

Fremlin's list of bacteria cannot be taken as complete, even as limited to the samples examined, because, as he points out himself, he did not exhaust the possibilities of other culture media producing additional kinds of growth, and did not enter into the question of anaërobic organisms. As his list, however, is fairly typical, in all important respects, of the organisms generally found by other recent workers, it does not seem necessary to enter into a detailed account of other researches on the subject.

General Results.

Considering, as a whole, the results obtained by different investigators working independently upon material obtained from different sources, there seems to be satisfactory ground for the conclusion that the vast majority of the extraneous organisms generally found in fresh lymph are, individually, harmless, or at least not appreciably injurious, saprophytes. Staphylococci, which are present everywhere, are naturally found almost invariably, but the varieties which have been examined have not, as a rule, exhibited pathogenic properties such as would indicate a serious danger on their being introduced into the human skin. Streptococci are found less frequently, and usually prove to be of a non-virulent type. The many varieties of bacilli, too, which are commonly found, as well as the more occasional yeasts and moulds, are not pathogenic. These results as to the bacteriological contents of fresh calf lymph are in general accordance with the relative slightness of the risk which was found to attend vaccination even in the earlier days before people realized the desirability of submitting lymph to a process of purification prior to using it for inoculation on the human subject. As lymph inoculated directly from a baby of doubtful cleanliness and history only proved pathogenic in a very small percentage of cases, it was not to be expected that the fresh lymph of a healthy calf kept

[23] Supplement to Report of Local Government Board, 1899-1900, p. 605.

under strict supervision would be found to be a fertile source of dangerous micro-organisms. But although these bacteriological results are satisfactory as far as they go, they do not justify, and are not intended to justify, the idea that the presence of these extraneous organisms in the lymph as used for vaccination purposes is a matter of no importance. On the contrary, a preliminary process of purification is, as is generally recognized by bacteriologists, most desirable for two reasons: (1) It is an important extra precaution; the chance that 1 out of 100,000 organisms inoculated will prove pathogenic may be very small, but it becomes very much smaller when we reduce the 100,000 to some half-dozen or fewer. (2) The inoculation, in any bulk, of so-called "harmless" saprophytes is by no means a matter of indifference; the products which are absorbed into the circulation from these organisms are not at all of a desirable nature, and though, in a healthy subject, their effect may be masked in the general disturbance of vaccinia, it may in less vigorous organisms contribute an additional disturbing factor of its own; the saprophytic element must therefore always be eliminated as far as possible, and the statement that they "make no difference" can only be accepted as true in the limited sense that the presence of a small number of them does not constitute a danger, and is therefore productive of no consequence in any degree comparable to the danger which would ensue from the presence of a similarly small number of virulent organisms.

We must now consider exceptional cases and possibilities. While recognizing that the presence of virulent organisms in fresh calf lymph must at least be extremely rare, we naturally want to know whether, under exceptional circumstances, this dangerous element may be forthcoming. Has, for example, the presence in fresh lymph of virulent streptococci, of tetanus or anthrax bacilli, or of the true bacilli of diphtheria or typhoid ever been bacteriologically verified? With regard to all these organisms, except streptococci, the negative results of the numerous bacteriologists who have endeavoured to find them are such as to give us every confidence in supposing that they do not occur. Of course vaccine lymph is prepared all over the world, and it is therefore unwise, considering the impossibility of making oneself acquainted with the results of every bacteriological examination of it, to state with absolute dogmatism that they have never been found. But we are at all events fully justified in stating that their occurrence, if ever recorded at all, is so extremely exceptional that it cannot be taken as a datum in evidence of a general danger. The same may be said with regard to the streptococcus of erysipelas, which has been found once or twice in lymph; the instances of its occurrence are so few and isolated that it is hardly thought of as one of the possible contaminating influences from which calf lymph must be freed in the process of preparation for clinical use.

The general public, then, may find considerable grounds for reassurance in the fact that, even before the customary period of purification, the organisms present in calf lymph are not of a virulent character. But it is important to recognize the nature of the guarantee upon which this freedom from dangerous contamination is based. It depends entirely upon a purely personal factor—the efficiency of the authorities who are responsible for the selection, care, and treatment of the calves from which the lymph is obtained. Any shortcoming on their part would immediately bring very distinctly into the horizon of possibilities the danger of introducing into calf lymph many varieties of highly pathogenic organisms. We must therefore consider the main precautions which are taken in the production of animal vaccine to obviate this danger.

Production of Animal Vaccine.

This subject was first worked out abroad. The systems adopted both in Germany and France at the leading vaccine institutes for the production of animal lymph on an extensive scale are in the main essentials the same, although there is considerable variation in many of the details. The points of main importance are the following:

The type of animal chosen is generally a calf, four or five months old, but varies with the local conditions of the market supply. When healthy animals of about this age are not obtainable in the district, either they are imported from elsewhere, or older animals, from 1½ to 2 years of age, are used instead. The delicacy of the animal's skin is a point to be considered.

The animals selected are placed in quarantine for about six days, carefully examined, their temperature taken daily, and any evidence of diarrhoea or other disease looked for. The tuberculin test is also applied in many places.

At the end of this time, if the animal has not betrayed signs of any ailment it is removed to the stable at the vaccine institute. The accommodation there has been arranged with every possible sanitary precaution. A stable which has never been used for animals intended for any other purpose is considered very desirable, and the absence of dangerous infective organisms in the chamber is confirmed by bacteriological tests.

The animal is again thoroughly examined and, in some places, submitted to a preliminary cleansing process.

When the operation is to be performed the animal is generally strapped to a sterilized table. The intended vaccination site and an area for some distance around it is very carefully shaved, and the area then thoroughly cleansed as for a surgical operation. A vigorous use of soap and water is followed by the application of some efficient disinfectant, such as mercuric chloride, carbolic acid, or lysol, and finally the disinfectant is removed by washing with sterilized water. Surplus moisture is mopped up with sterilized sponges.

The inoculation is made by linear incisions, the material used being generally calf lymph, sometimes glycerinated human vaccine lymph, and, very occasionally, glycerinated material from cases of variola. In the last case the vesicles produced are not utilized for human vaccination, but the material collected from them is passed through a series of calves, and not until it is thoroughly established that typical vaccinia is produced in the calf is the material finally obtained prepared, after careful bacteriological tests, for human vaccination.

When the operation is over the attempt is sometimes made to protect the inoculated area by applying some sort of covering which, while offering no hindrance to the development of the vesicles, will protect them from external contamination. A material which is fashionable for this purpose in many of the institutes, following the example of Paul of Vienna, is a paste, composed of wax, glycerine, water, and zinc oxide, which is spread over the area, and then covered with some protective material. This "Tegmin," as it is called, is, according to Umlauf's[24] account of the employment of it in Vienna, removed after two or three days, provided it sticks on so long, and then renewed once or twice before the vesicles reach maturity. When finally pulled off, the vesicles ought to be found in perfect condition, and contaminated with comparatively few extraneous organisms. In some of the German institutes which use this form of protective its employment is found, according to the official summary of their operations which is issued annually, to be extremely troublesome. It seems to frequently develop the habit of constantly coming off, or, more provoking still, half of it will come off, whilst the other half will stick on with such persistent adherence that it cannot be separated without damage to the vesicles beneath it. However, in spite of these difficulties, many authorities continue to advocate its employment, on the ground that it diminishes the number of extraneous organisms, and—a fact which is a proof of their good faith—persevere in its use. As an alternative to the "Tegmin," other devices are sometimes adopted, such as an arrangement for tethering the animal in its stable, so that it may either stand up or lie down, but is unable to lick the affected surface.

The vesicles are matured in about five days, but the time varies with the temperature, being shorter in hot weather and longer in cold. When ready the animal is again removed to the operating table, and aseptic precautions are observed similar to those of the initial operation. After the vaccinated surface has been sterilized and the excess of disinfectant removed, any crusts and superficial débris present are carefully taken away, and the contents of the vesicles are then removed with a Volkmann's spoon, every care being taken to avoid admixture of blood. The material thus collected is then weighed, triturated, and glycerinated with 50 per cent. of pure glycerine. Throughout the procedure, the instruments and

[24] *Zeit. f. thier. Med.*, 1899, Bd. iii, H. i, p. 26.

other apparatus used and the hands and outer clothing of the operator are supposed to be sterile.

The calf is slaughtered the next day, and the carcass examined by a veterinary surgeon. If any pathological lesion is found, all the lymph collected from that animal is discarded. Even if the report is satisfactory, a bacteriological examination of the fresh lymph is made.

The above is a brief outline of important steps in the process which are of interest from a bacteriological point of view. Minor points vary more or less in different stations, but the essential conditions are, in every well-regulated establishment, practically the same. In fact there is no possibility for divergence on fundamental points, because there really are only two essential conditions—skill and cleanliness—and these must necessarily be observed in every institute which produces satisfactory material. We want good vesicles, and therefore require skill in the selection of animals, care in performing the operations, and the capacity to discriminate between what is a typical healthy vesicle and what is not. We also want the greatest possible freedom from extraneous organisms in the lymph, the fulfilment of which need demands a knowledge of practical bacteriology and an observance of the principles of aseptic surgery. These two main requirements being satisfied, the arrangement of the details may be safely entrusted to the authorities concerned. There need be no hard-and-fast rule as to the age or sex of the animal to be operated on or the kind of disinfectant to be used or the mode of applying it; some operators may like to apply a protective paste or other material over the vaccinated area; others may find that it is more trouble than it is worth, and that they get very good results without it. All such matters are of subsidiary importance, and may very properly be left to the choice of the operator; it is not upon the routine details themselves that the success of a lymph depends, but upon the personal skill with which they are carried out. And the part played by the veterinary surgeon in inspecting the carcass of the animal must not be forgotten. It occasionally happens that a calf which has appeared in excellent health throughout the time it has been under observation presents, *post mortem*, lesions of a quite unexpected character. For example, Blaxall, in his report on the operations of the glycerinated calf lymph establishment in London for the year 1899-1900, says that lymph was obtained from 271 calves, all of which appeared healthy until necropsies were made. Two were then found to present tuberculous lesions in certain glands and other organs (a rare disease for calves in this country). Of course lymph is never issued until the veterinary report has been received, and, it need hardly be added, all the lymph collected from these two sources was immediately destroyed. There must also be kept in mind the possibility, which of course is only a remote one, that an apparently healthy animal is really in the early stages of some internal infective process caused or accompanied by dangerous organisms which, from their capacity to form spores or by other means, might be able to resist the action of glycerine for a lengthy period. The proved absence of internal lesions is therefore a further guarantee that the extraneous organisms removed with the lymph are not likely to be pathogenic.

In England the production of animal vaccine on an extensive scale and with proper bacteriological precautions was introduced somewhat later than abroad. In order to study Continental methods, the late Sir Richard Thorne Thorne and Dr. Copeman visited the leading establishments in Paris, Brussels, Berlin, Dresden, Cologne, and Geneva, and reported their observations to the Local Government Board,[25] speaking in terms of high praise of the cleanliness, sanitary provisions, and arrangements for bacteriological work which they found adopted. The general principles of conducting the process which they found to be observed abroad were similar to those subsequently adopted in England by the Local Government Board.

As regards the private English firms which prepare animal lymph, there appears to be a general anxiety to conform to most of the principles already laid down as necessary for obtaining a vaccine which when taken from the calf shall be as free as possible from extraneous organisms. There is only one comment which need be made upon their methods.

[25] Supplement to Report of Local Government Board, 1896-7, p. 39.

As has already been pointed out, the essential condition upon which success depends is, at every stage of the process, the personal factor. If a bacteriologist with an established reputation for accurate work is directly responsible for the entire conduct of the work, his name alone is sufficient guarantee that every precaution is being taken against contamination. But the mere assurance that the work is being conducted under strict supervision or by trained experts does not give one the same degree of confidence in it, because the terms "supervision" and "expert" are somewhat vague and elastic. It may be very good or it may not; in any case it is very desirable that the element of doubt should be removed. The natural solution of the difficulty is that every institute which produces vaccine should be subject to periodical and official inspection by an impartial authority who would report upon the conditions under which the lymph was prepared and upon its character as actually turned out. An arrangement of this sort would not only be of obvious utility to the general practitioner but would also, by giving the best "brands" the stamp of official approval, be a commercial advantage to the firms whose goods deserve a wider appreciation.

3. The Action of Glycerine.

Fresh lymph practically always contains extraneous microorganisms. Though not usually pathogenic individually, these organisms are generally present in undesirable abunddance, and it has become generally recognized that they ought as far as possible to be eliminated before the lymph is used for human vaccination. The object is to eliminate extraneous germs without impairing the specific virus. For this purpose glycerine is the only medium which has met with success, and need alone be considered. We now proceed to discuss its action.

Historical.

Glycerine was first used merely as a diluent. Müller was the first to make it clear, in 1868, that the addition of glycerine, whilst increasing the quantity of lymph available for vaccination, did not impair its efficacy. Then, when the impetus to bacteriological research was given, glycerine was found to be convenient not merely as a harmless diluent, but as a useful addition to culture media. Thus, as Copeman points out in his Milroy Lectures,[26] Quist, in 1883, searching for a specific organism, used as a culture medium an alkaline mixture of equal parts of blood serum, glycerine, and distilled water, and, though not very successful, at least established the fact that the specific contagium could continue to exist in a fluid containing a considerable proportion of glycerine. In course of time the use of glycerine in the laboratory and the recognition that it exercised a selective action, killing or inhibiting extraneous organisms whilst leaving the specific germs intact, began to take practical effect in the shape of recommendations that glycerine should be used as a purifying agent for lymph intended for clinical use. The widespread adoption of these recommendations, both in Europe and America, has led to most valuable practical results, and it is only natural to find that many countries claim the credit of the original discovery that glycerine is bactericidal to the extraneous organisms present in vaccine lymph. In Italy, Leoni appears[27] to have shown in work commenced in 1888 and published in 1890 that on the addition of glycerine to lymph the extraneous organisms speedily die, whilst the specific infective agent survives and remains effective much longer. The Germans claim the priority for Schulz, of Berlin. In their official journal[28] they speak of glycerination for the purpose of killing extraneous organisms as "a simple procedure discovered by him and hitherto unknown," and state that the method has been abundantly employed in their institute since 1888. In England we very properly attach considerable importance to the work which Copeman brought forward on the subject at the International Congress of Hygiene in 1891, and in later publications. To the French authorities—St. Yves Ménard, and Chambon,[29] must also be given the credit of distinctly recognizing the bactericidal value of glycerine in 1892.

Whilst each of the above investigators has rendered a

[26] British Medical Journal, May, 1898, pp. 1185, 1245, and 1312.
[27] *Centralbl. f. Bakt.*, Bd. xxiii, 1898, p. 345.
[28] *Med. statist. Mitth. aus dem k. Gesundheitsamte*, Bd. ii, 1892, p. 51.
[29] *La Sem. Méd.*, 1892, p. 488.

very valuable public service in bringing the importance of the action of glycerine into official recognition, and thus giving the impetus to a most useful reform in vaccination methods, it seems more appropriate to appreciate their work by the practical utility resulting from their advocacy of a recognized bacteriological fact, rather than to lay too much stress on individual claims to the credit of a scientific discovery. The property of glycerine, which has led to so many controversial claims as to priority of discovery, was fairly well known to bacteriologists some years before any of those claims were put forward. As early as 1883, in an article previously quoted,[30] which deals with Koch's investigations into the micrococci of vaccine, we find the following remarks: "Freshly prepared glycerinated lymph does indeed contain vaccine micro-organisms, but their growth on culture media only proceeds very slowly, especially if kept in the warm incubator ..... Older glycerinated lymph produces on nutritive media few specific micro-organisms or none at all, although it still retains its efficacy for the vaccination of children." As already mentioned, the final conclusion arrived at in the same article is that these "vaccine organisms," although constantly to be found, are not really specific. Since therefore it was recognized in 1883 that organisms in lymph, admitted to be non-specific, diminished in numbers and might even entirely disappear when the lymph had been preserved for some time in glycerine, it is unnecessary to consider claims to the priority of that discovery which were made some five or ten years later.

Experimental Data.

Glycerine is added to lymph in order to eliminate micro-organisms; but it must in the first place be pointed out that the addition of glycerine may actually introduce into the mixture bacteria which the lymph did not originally contain.

Deeleman[31] examined several samples of glycerine by inoculating agar culture media with them. If he used less than 2 c.cm. of glycerine for inoculation he invariably got a growth which presented the characteristics of the "potato bacilli" (B. mesentericus). The bacilli occurred in the form of their extremely resistent spores, and survived exposure to steam for three hours. Fortunately they are not pathogenic, but as Deeleman points out, it is very probable that they often find their way into glycerinated lymph, even when the glycerine used is supposed to be sterile. In fact it is not unlikely that they have sometimes deceived people into imagining that they had discovered in them the specific micro-organism of vaccine. Deeleman's observation that if as much as 2 c.cm. of glycerine were used no growths ensued is also interesting as another illustration of the fact that if present in sufficient quantity glycerine may inhibit the growth of organisms which it is powerless to kill.

Deeleman then proceeded to test the bactericidal action of undiluted glycerine on a bacillus isolated from lymph and on yellow staphylococci, and found that with all the samples of glycerine used the result was approximately the same. The temperature at which the glycerinated material was kept was an important factor. In the ice chamber, although the organisms very appreciably diminished in numbers week by week it was two months before they were completely annihilated. But when kept in the warm incubator there were very few left at the end of the eighth day, and by the seventeenth the material was sterile. He says similar results attended his experiments with dilutions of glycerine, and points out in another article that a 50 per cent. solution is most effective. He recommends that the vaccine should be kept in it for not less than two months nor more than five before being used. Frosch made similar experiments as to the effect of glycerine upon other species of bacteria, and found that streptococci were killed at room temperature in eleven days, and virulent diphtheria bacilli in twenty days. In the ice-chamber the streptococci lived for eighteen days, and the diphtheria bacilli for three months. The experience of Schulz is practically the same, but he regarded 60 per cent. as the most effective dilution. He agrees that 37° C. is the optimum temperature, and finds that at that temperature the cocci of erysipelas are killed in four days. He has also shown that tubercle bacilli are less resistant to the action of glycerine than is the specific organism of vaccine. Kirchner,[32] working upon the same subject at the Vaccine Institute in Hanover, found that the large number of organisms contained in fresh lymph rapidly diminishes under the action of glycerine, so that after two or three months they have "almost completely" disappeared, and the lymph may then be regarded as "practically sterile." In none of the samples of lymph he investigated was he able to find pathogenic bacteria. It is worthy of note that this observer, whilst confirming the value of glycerine, refrains from damaging his case by attempting to exaggerate its importance. He also makes the common-sense remark, which is often in danger of being forgotten, that "in order to avoid complications of bacterial origin, careful disinfection of the instrument and the skin of the patient before inoculation and the protection of the pustules from contamination afterwards are much more effective than the use of so-called 'germ-free' lymphs."

The observations of Calmette and Guérin[33] are also well worth bearing in mind by those who are disposed to take an extreme view of the efficacy of glycerine. Speaking of its bactericidal action, they say: "This property is not as absolute as people have maintained. Old glycerinated vaccines of ages ranging from two months to two years no longer, indeed, contain microbes which can be cultivated on gelatine or agar; but if we inoculate them into bouillon and incubate them at 37° for two or three days, they constantly give rise to a bacterial growth."

Coming now to English researches on the subject, there are some interesting details in the work done by Fremlin.[34] He finds that the primary effect of the glycerine is inhibitory merely, but that by the end of the second week there are very few living organisms left. "As a rule, a fresh glycerine emulsion which on plate cultivation shows 120,000 colonies will, one week after, show an average of 700 colonies per loopful; two weeks after, an average of 50 colonies per loopful; three weeks after, an average of 10 colonies per loopful; four weeks after, there are usually no colonies noted in one loopful." All the micro-organisms are not equally susceptible. "Staphylococcus pyogenes albus usually disappears by about the third week at 20° C." Staphylococcus pyogenes aureus is slightly more persistent, a few colonies being found in the fourth week. The "unnamed bacillus," which has been described above, is very resistant. "The number of its colonies which appear on the plates is much reduced at the end of the fourth week, but some colonies may be found many weeks after the pulp has been glycerinated." The spores of penicilium glaucum and the hay bacilli—all micro-organisms which spore very readily—are little, if at all, affected by glycerine.

There is an interesting experiment recorded by Blaxall[35] upon the resisting powers of the tubercle bacillus when purposely introduced into glycerinated lymph. Guinea-pigs A and B were injected subcutaneously with 1 c.cm. of vaccine emulsion to which tubercle bacilli had been added, and which had subsequently been kept at 37° C. for a month. Guinea-pigs C and D were inoculated with 1 c.cm. of the same material which had been kept in the cool instead of the warm incubator for a month. Guinea-pig E was inoculated with a loopful of the same culture of tubercle bacilli which had been used for artificial contamination of the lymph. "When six weeks had elapsed, Guinea-pigs A, B, C, and D still showed no signs of disease and were quite healthy, whereas Guinea-pig E was markedly tuberculous."

As regards the effect of the glycerine upon the specific vaccine virus there is not much to be said. There seems to be a pretty wide consensus of opinion that vaccine will keep for five months in glycerine without deteriorating. Plenty of instances are recorded in which glycerinated lymph was proved to be fully effective after being kept very much longer; it is, however, wiser for clinical purposes not to trust to a lymph which is more than five months old.

The only other point to which attention need be called is that lymph keeps best in a cool place, preferably in an ice-chest; under these conditions, however, the bactericidal action of glycerine is much slower than at higher temperature.

[30] *Deut. med. Woch.*, 1883, p. 500.
[31] *Arb. aus dem k. Gesundheitsamte*, Bd. xiv, p.144.
[32] *Zeit. f. Hyg.*, Bd. xxiv, 1897, p. 530.
[33] *Ann. de l'Inst. Past.*, 1901, T. xv, p. 161.
[34] Supplement to Report of Local Government Board, 1899-1900, p. 605.
[35] Supplement to Report of Local Government Board, 1897-98, p. 335.

General Results.

The value of glycerine is extremely great, but it is unwise to exaggerate its importance by endeavouring to show that it will produce a vaccine emulsion which is completely sterile. It has little or no action on many forms of spore-bearing organisms, and there are also some non-sporing bacilli which are highly resistant to it. Its bactericidal action is not always distinguished with sufficient care from an effect which is inhibitory merely. We must also expect that, at the low temperature at which vaccine material is, or ought to be, kept, glycerine will not produce all the bactericidal effect it is capable of producing in a period less than two months. Bearing these qualifications in mind, we may freely recognize that glycerine, as ordinarily used, actually does kill an enormous number of organisms, and thereby renders a very valuable service to the interests of vaccination. It is also satisfactory to know that the organisms which have been shown to survive in glycerine for more than about six weeks are almost always saprophytes, which, not merely owing to their non-virulent character, but for the further reason that they survive in such small numbers, may legitimately be disregarded as harmless.

At the same time, we must never lose sight of the fact that the less work there is left for the glycerine to do the better. It is to be regretted that well-informed people are sometimes over-zealous in their praise of the virtues of glycerine and make statements about its bactericidal action which lead persons whose bacteriological knowledge is incomplete into the notion that, no matter what dangerous organism is present in fresh lymph, a liberal treatment with glycerine is certain to eliminate it. No doubt the original authors of such statements are much too careful themselves to permit of any negligence, as regards the work for which they are themselves responsible, in dealing with the animals from which the fresh lymph is derived. But, under present conditions, there is no safeguard to prevent less intelligent people from undertaking to supply vaccine lymph; it is, therefore, somewhat disconcerting to think that if such persons are induced by an over-implicit confidence in glycerine to think that initial precautions in lymph production do not matter very much, disastrous consequences might at any time ensue. There are two guarantees for the safety of a lymph prepared for clinical use. The first is the skill and cleanliness in the procedure leading to the production of vesicles in the calf; the second is the purification of the fresh calf lymph by means of glycerine. It would be most undesirable to dispense with either guarantee, but it would be absolute folly to neglect the first. Glycerine cannot kill any and every organism indiscriminately which negligence has put in its way, and, therefore, whilst appreciating the value of its services, we must never forget the limits of their application.

4. IMMUNITY.

Given a vaccine lymph which is both active and free from any extraneous contamination capable of producing an appreciable effect, the next question to consider is the amount of protective power it is likely to confer.

The problem of immunity in variola and vaccinia is not a very satisfactory one to deal with, because so little is known about it. On the theoretical side we find that, although a considerable impetus has been given lately to the study of immunity in infectious diseases, when the bacteriologist comes to deal with variola he is very heavily handicapped by his ignorance of the specific organism. Considering that the work is difficult enough, and indeed still only in its infancy, in diseases with a fully accredited bacteriology of their own, it is not reasonable to expect that the workers who are investigating small-pox on similar lines should, as yet, be able to carry us very far. On the clinical aspect of the question we have, on the one side, an enormous number of data which all point to the same general conclusions; and, on the other side, a very much smaller number of isolated instances which do not strictly harmonize with the former data, and which we can only explain, until we receive further scientific enlightenment, on the ground of individual idiosyncrasy.

Laboratory Experiments.

The most systematic work which has been done upon the scientific aspect of immunity in vaccinia is that of Béclère, Chambon, and Ménard. As the result of their work published in 1896,[36] they found that the serum removed from an animal ten to fifty days after vaccination possesses immunizing properties against vaccinia. The immunizing action of this serum is very rapid. Injected subcutaneously in sufficient quantity immediately before vaccination, it modifies the subsequent development of vesicles and may prevent their maturation. On the other hand, the immunity conferred by vaccine is very much later in making its appearance. At first they estimated that it was postponed for about three days; but in a later article on the same subject,[37] they estimated that eleven or twelve days were requisite for the immunizing effect to be fully developed. Contrasting this difference in the time requisite for the action of serum and the action of vaccine, they infer that "this serum owes its immunizing properties to some soluble substances, and not to the presence in its bulk of the microbes (as yet unknown) of vaccine."

In 1899[38] the same authors published an account of their study of the action *in vitro* of serum from a vaccinated calf upon vaccine virus. They took as the starting point of their experiments the observation made by Sternberg[39] and confirmed by Kingoun—that a drop of vaccine, mixed with four drops of serum from a calf vaccinated a fortnight previously, loses in an hour's time the power of producing vaccinia. Their own method of procedure was to take 5 or 6 c.cm. of serum from a vaccinated animal and leave it in intimate contact with 20 or 30 c.gm. of vaccine lymph for twenty-four hours. The lymph was then allowed to settle for twenty-four hours, after which it was removed, as free from the serum as possible, and used for their experiments. The vaccine thus treated was found to have lost its efficacy, whereas vaccine which had been brought into contact with the serum of normal animals or men retained its specific powers. This effect upon vaccine which is produced by the serum of a vaccinated animal may be brought about not only by the serum of calves, but also by that of vaccinated horses and men. They describe it as an "antivirulent" property, and find that it is forthcoming in the serum in whatever way the vaccine has been introduced into the organism. The same antivirulent action upon vaccine virus is demonstrable in the blood of convalescents from variola. This antivirulent substance contained in the serum both of immunized men and animals is of a remarkably stable composition. It is still found in serum which has been kept a year or more, and resists the action of light, heat, and even putrefaction. When dried it will resist a temperature of 100° C. for thirty minutes without any impairment of its activity, and does not appear completely destroyed by a temperature of 125°. It will pass through a porcelain filter, but appears incapable of dialysis; it is precipitated by alcohol with the albuminoid substance of the serum, and appears to attach itself to the globulins. The authors have not yet been able to determine its nature, but think it presents striking analogies to the diastases, and, in its resisting powers and other chemical properties, they point out the resemblance it presents to anti-bodies found in animals immunized against rabies, tetanus, and diphtheria, and to the agglutinating substances in the serum of typhoid patients.

Discussing the duration of immunity, which is very variable in different species, after vaccinia or variola, they say that it may be divided into two successive phases. In the first the blood preserves its antivirulent properties, which progressively decrease; in the second there is no longer any demonstrable evidence of the antivirulent power, but the skin still resists fresh inoculation. In the first phase of immunity the antivirulent substance can traverse the placenta and reach the fetal blood, but the infant's immunity is only of the "passive" kind, and of very short duration. In man, where immunity lasts longest, they claim that it is, in certain cases, possible to demonstrate the antivirulent substance twenty-five or even fifty years after vaccinia or variola. Curiously, however, in certain revaccinated subjects the antivirulent substance only manifests itself in the serum for a few months, or even only for a few weeks or days, and may never be detected at all.

[36] *Ann. de l'Inst. Past.*, 1896, T. x, p. 1.
[37] *Ann. de l'Inst. Past.*, 1898, T. xii, p. 837.
[38] *Ann. de l'Inst. Past.*, 1899, T. xiii, p. 81.
[39] *A Manual of Bacteriology*, New York, 1892, p. 262.

It is as yet quite undetermined where or how this substance is produced, and in what mode it is eliminated; nor do we know whether its action is directly inimical to the unknown infective agents, or whether it produces its effects mediately, as a specific cell stimulus.

It has long been held that in scraping out the vesicle of the calf in the course of lymph preparation every care must be taken to avoid admixture with blood, on the ground that any contamination with that substance diminishes the efficacy of the lymph containing it. The scientific reason for this deterioration may be readily understood in the light of the researches just described. A systematic confirmation of this practical corollary deducible from Béclère's work has recently been provided by Kodjabascheff[40] who has utilized his position as director of the Vaccine Institute in Sofia for making a series of observations upon this point. His statistics appear to make it quite clear that, when all the other conditions are identical, the lymph pulp from those vesicles of the calf which have been slightly contaminated with blood in the process of removal produce an inferior vaccine to those free from such admixture.

Calmette and Guérin published last year[41] some experiments upon vaccinia in the rabbit which they believe capable of being turned to practical account. This animal is not readily susceptible to vaccinia but they find that if a powerful vaccine be used and the precaution be taken of simply rubbing the material over the freshly shaved skin, instead of inoculating it into scarifications, it will always "take," as evidenced by a confluent eruption of small pustules rich in lymph. Similar characteristic pustules will also make their appearance if the vaccine be administered intravenously and then, within twenty-four hours, an area on the animal's back be shaved. The pustules appear at the site selected on the back and nowhere else. As the rabbit will only react to a fully virulent lymph, they think this animal might be utilized for test inoculations to determine the efficacy of a lymph intended for public vaccination.

They are also attempting to utilize the bactericidal properties of the rabbit's peritoneal fluid as a means of purifying lymph. They first inoculate intraperitoneally 10 to 20 c.cm. of bouillon so as to stimulate the formation of an exudate. Four or five hours afterwards they introduce a small quantity of fresh glycerinated vaccine diluted in 1 c.cm. of bouillon. In four hours' time the exudate is withdrawn; it is found to be aseptic and to produce the effects of a dilute vaccine. This difficulty of excessive dilution they do not as yet appear to have overcome.

Further attempts to utilise experimental methods for the purpose of making an approximate estimate of the duration of immunity after vaccinia, or of determining its presence or absence, do not as yet appear to have met with much success. Martius[42] has recently been working on the subject in Berlin by the method of inoculation experiments on calves, similar to those of the French observers, using vaccine to which a sample of the serum to be tested has been added. He confirms Béclère's "antivirulent" property, which he found practically absent in the serum of people who had not been vaccinated for a very long time, but present in a high degree in the serum he examined of a man who had been thoroughly well vaccinated. But a few extreme instances of this sort are not, alone, of very much value, and there appears to be such a very large number of doubtful results, where the serum-treated vaccine produces a questionable lesion which might or might not be an abortive pustule, that the method does not afford much promise of ever being able to give us a scientific determination of the duration of immunity.

General Statistics.

Except for purposes of polemical discussion it is not considered necessary nowadays to bring forward the vast array of statistics which have accumulated to show that vaccinia actually does confer immunity against variola. In a scientific consideration of immunity we may be expected to take so much for granted, and devote our attention to more interesting and doubtful minutiae. There is some little danger, however, that in dealing solely with the exceptional cases, which we naturally regard as of exceptional interest, we may place their importance in a false light and overlook the significance of the fundamental laws in our efforts to explain apparent deviations from them. It is, therefore, useful to recall the three elementary facts upon which our knowledge immunity in these diseases is based: (1) Variola protects the survivor for a long period, generally for life; (2) a primary vaccination protects against variola, but not for so long a period, the protective power progresssively diminishing with time, but being capable of renewal by revaccination; (3) susceptibility to variola is inversely proportional to the efficiency of vaccination and revaccination. The first of these facts is based upon clinical evidence; the second and third upon the diminished incidence of small-pox and lessened percentage mortality since the introduction of vaccination, the immunity of well-vaccinated persons in daily contact with small-pox cases, and the progressive increase in mortality from the disease according as the patients present good vaccination scars, poor scars, or none at all. These are the main facts, based upon an enormous number of cases; the number of exceptional cases is, in comparison, quite insignificant; deductions from the latter are interesting, and may be valuable, but they are powerless to invalidate the laws established by the former.

Coming to some of the less generally observed details, we may avail ourselves of the survey of the literature which has been made by Huguenin.[43] Concerning the effect of vaccination upon persons who are already in the early stages of infection with variola, his general conclusions are as follows: (1) If the person is vaccinated immediately before or during the first fever of variola, the latter disease breaks out and takes its course. (2) If vaccination takes place at the end of the incubation period of variola, the eruptions of both diseases will probably make their appearance. (3) If it is performed at the middle of the incubation period, the course of variola will be favourably influenced; the disease will appear in a mild form or only as a varioloid. (4) If at the beginning of the incubation period, the variola is still more considerably modified. (5) If performed on the first day, the only evidence of the variola will be a transitory rise of temperature. (6) If after exposure to but prior to actual infection, the person will be immune.

Huguenin has collected recorded cases in which variola has been known to attack the same person more than once. Out of these we may select a few interesting examples. Cantani quoted the case of a woman who survived six attacks of variola and died of the seventh; Webb a woman who had variola three times; Marmise a 5-year old girl who had had small-pox when aged 3 months, and died of the second attack; the girl's mother and brother had each had small-pox twice. Other examples are quoted to show that particular families may possess an abnormal susceptibily to the disease, and that this idiosyncrasy is hereditary. This is the opposite extreme to the cases which have been recorded of natural immunity. Statistics derived from different sources as to the frequency of a second attack of small-pox in the same person vary very considerably; Huguenin, from an extensive investigation and comparison of these, puts it down as 1 out of every 3,000 cases of the disease.

With regard to the duration of immunity after vaccination, it is impossible to make any general statement of a precise nature. The extreme variability of the personal factor, the difference in the number of insertions and in the value of the lymph used, the element of doubt in a person's statement as to whether he "took" or not, the possibility that a failure to "take" may be due to badness of the lymph and not to insusceptibility, are considerations which introduce so many unknown elements that no set of statistics on the subject can be taken as a basis on which to draw up general principles. Of such statistics perhaps some of those which have been compiled on the Continent, dealing with revaccinations of school children and revaccinations of persons joining the army, are, so far as they go, as good as any. But sometimes, especially when we are dealing with unknown qualities and not with unknown quantities, an excess of mathematics is apt to obscure the truth. The rough practical rule to vaccinate soon after birth, to revaccinate before puberty, and to vaccinate afterwards if the person is in any

[40] *Ann. de l'Inst. Past.*, 1900, T. xiv, p. 102.
[41] *Ann. de l'Inst. Past.*, 1901, T. xv, p. 161.
[42] *Arb. aus dem k. Gesundheitsamte*, Bd. xvii, Heft 1, 1900, p. 156.
[43] Pocken, *Lubarsch u. Ostertag's Ergebnisse*, 4th Jahr., 1899, p. 246.

danger of being brought into contact with small-pox, really embodies the sum of our theoretical knowledge. We know that most people will give two good reactions in their lifetime, and at some lengthy period after the second a third, probably imperfect, reaction. We also know that some people will give more than two complete reactions, and that a few, though very few indeed, are naturally immune. The most elaborate vaccination statistics which have ever been devised will not teach us much more than that. The present obscurities of the subject may be cleared up at some future date; but the work will be done, not in a quantitative fashion by calculations of percentages, but in a qualitative fashion by chemistry. When the bacteriologist has learnt the chemistry of the compounds which determine immunity we may look for an explanation of what is at present the unknown variability of the personal factor; until we have got the essential clue it is futile to seek for an explanation amongst accessory consequences.

It is a curious and unexplained fact, which is another indication that we have not yet got the key to the problem of immunity, that whereas persons who are efficiently vaccinated are extremely unlikely to contract variola, persons who have had small-pox, and therefore would in all probability not be infected a second time, are by no means uncommonly susceptible to vaccinia. Quite recently[44] Dr. Sinigar, of Leavesden Asylum, vaccinated 1,060 adults, 45 of whom provided evidence of having had small-pox. Of these 45, 40 were vaccinated successfully. Now, as no one would dream of asserting that out of any series of 45 recoveries from variola, 40 are susceptible to a second attack, this is a very good illustration of the widely recognized fact that, if one were given the choice of a protective against small-pox, apart from all considerations of personal inconvenience, a dose of variola would be distinctly less valuable than an efficient course of vaccinia.

It is generally recognized to be an error in judgement to find fault with an exploded theory, but it is not always easy to know, whatever one's personal convictions may be, whether one is entitled to disregard a theory as being fully exploded or not. Hence every writer of an article on the present subject seems to feel it incumbent on him, as a dutiful safeguard against self-presumption, to give a reason for thinking that variola and vaccinia are not independent diseases with no essential connexion between them. The reason is simply this—it has been established irrefutably by many observers in different countries that by the inoculation of human variolous material into calves true vaccinia can be produced. It is not necessary here to argue the matter in further detail, but a few points may be referred to which are of some interest in the discussion of immunity. When the contagium from a virulent case of small-pox is transplanted into a calf, the conditions on which its vitality depends are profoundly disturbed owing to the sudden and radical transformation of its environment. It is not an easy matter for the contagium to adapt itself to its new circumstances, and in the effort to do so it may die out. It may, however, succeed, given time and the opportunity, and will then ultimately transform itself into the specific contagion of typical vaccinia. It must not, however, be expected that the calf directly inoculated with virulent variolous material will promptly develop typical vaccine vesicles. The process of modification will take longer than that; the vesication obtained in the original calf will be atypical, but the material obtained from it will produce much better vesicles when inoculated into a second calf, and, after passage through a few animals, absolutely typical vaccinia will result. If, however, the variolous material has already been partly modified by inoculation into a healthy person, its assimilation by the calf and transformation into typical vaccine is much facilitated. This was probably the source of much of the cow-pox in the old days, when human inoculation of variola was customary, and is still, as pointed out by Daniels,[45] utilized in Central Africa as a convenient method of starting a fresh supply of vaccine. The natives on the outbreak of small-pox are in the habit of practising variolous inoculation among themselves of their own initiative. From a primary vesicle so produced it is found that a calf can readily be vaccinated. In this country, where legal restraints do not permit such a practice, a monkey may be made to serve the same purpose.

It follows as a corollary from these considerations that material from a virulent case of variola, since it takes some time to transform itself into innocent vaccine, does not necessarily lose its malignant properties immediately it is introduced into a calf. If a person is so foolish and so ignorant as to think it does, and is, moreover, so unscrupulous as to take material from an obviously atypical eruption so produced and inoculate a child with it, it is only in the natural course of events that that child may die of confluent small-pox.

However, the enthusiasm of controversy upon this subject is rapidly dying out. If the reader is interested in a general survey of the work which has been done upon the relations between variola and allied affections, he may be referred to the original articles published[46] a short time ago by Bruno Galli-Valerio of Lausanne. The articles may be recommended as dealing with the relation of small-pox to comparable diseases in the cow, horse, sheep, pig, and other animals, as reproducing the leading arguments of the "dualists," with many references to their works, and as infusing into the subject something of that polemical vigour which most people nowadays find it difficult to revive.

Conclusion.

The obvious common-sense view to take of the question of immunity is to accept the main facts, which have proved the immunizing power of vaccination beyond any doubt; to regard the exceptional cases with interest, but to await for their explanation until we receive further enlightenment, which is more likely to come from the scientific laboratory than from clinical observation; and, in the meantime, not to distort their significance.

5. Practical Deductions.

It remains to consider whether the principles hitherto discussed can be of any guidance to the general practitioner whose main desire is to know the best means of vaccinating efficiently and safely.

The Choice of Lymph.

Can glycerinated animal lymph, provided it be good of its kind, be relied upon to prove as efficient as any other kind of lymph? The answer to this question may be unhesitatingly made in the affirmative. There are, it is true, practitioners who still have their doubts about it; that is only natural, because the time since arm-to-arm vaccination has been superseded in this country is not very long, and people who have always obtained good results with the old method may be expected to adopt a critical attitude towards the present innovation, and regard it as still on its trial. If, however, a fair consideration be given to the results obtained from glycerinated calf lymph both in Germany and America as well as in this country, it seems impossible to escape the conclusion that this form of lymph has already passed beyond the period of probation, and fully proved itself capable of producing typical vaccinia and protecting people who are brought into immediate contact with cases of small-pox. There seems no reason to suppose that lymph from the calf may not be as good as lymph from a child, nor has any objection to the use of glycerine been established which in any degree counterbalances its advantage as a purifying agent. We may give a typical example of the sort of agitation in a small way which is got up from time to time against the use of glycerinated lymph. A number of physicians, in the United States for instance, vaccinate with glycerinated lymph and find it produces local reactions and, in some cases, what appear to be vaccine vesicles. Then to their dismay they find that if the persons so treated are vaccinated a short time afterwards with dry points a large number of them "take" in quite unmistakeable fashion. The inference is inevitable that the glycerinated material used was ineffective and a presumption is raised against the utility of glycerinated lymph in general. Whereupon some well known authority generally comes forward and makes clear the real nature of the difficulty. Thus, in the case alluded to, Welch and Schamberg write[47]: "Our experience with glycerinated lymph at the Municipal Hospital has been quite

[44] *Lancet*, April 5th, 1902.
[45] British Medical Journal, May 25th, 1901, p. 1303.
[46] *Centralbl. f. Bakt.*, Band xxv, 1899, p. 380 and p. 424.
[47] *Philadelphia Medical Journal*, vol. viii, 1901, p. 901.

different from that above quoted. It has been employed to the exclusion of all other forms of virus." They go on to show that the results obtained with it on nurses and other persons employed in the small-pox hospital completely established its thorough efficacy. Then they add, which of course gives the key to the whole mystery, that the lymph which they need was not, however, obtained from the same sources as the glycerinated lymph which other physicians found ineffective. That bad glycerinated lymph makes its appearance from time to time no one denies, and any agitation which would tend to eliminate it would serve a useful purpose; but a moment's consideration will reveal the unfairness of concluding from the badness of particular samples that the genuine article has not yet fully established its merits.

Since specimens of lymph obtained from different sources may vary in quality, the great practical difficulty which the practitioner feels is to know which particular brand he ought to select. It is not practicable for us to single out any particular firm for either praise or blame in this respect, because, amongst other reasons, the recommendation of any particular brand would be unfair to other firms whose merits were ignored, and, again, any unfavourable criticisms based upon particular samples of a brand which might on other occasions prove excellent would also prove misleading. We can only express the hope that at some future date all the institutes which manufacture lymph will be under the impartial control of a centralized and authoritative supervision, which shall provide for the practitioner a better guarantee than at present exists that the lymph he elects to purchase can be thoroughly relied upon. In the present state of affairs, the numerous complaints which have recently been made make it impossible to doubt that the amount of unsatisfactory lymph which has been put upon the market is sufficiently large to be productive of serious inconvenience. As a typical instance of these complaints we may quote the experience of Dr. Sinigar,[48] of Leavesden Asylum, who was recently called upon to vaccinate 1,060 adults. "The first important fact noted was the want of uniformity in the potency of different strains of lymph. Much has lately been written upon this subject, and our experience at Leavesden fully confirms the complaints which have been recently appearing in the medical press. Lymph was used from three different sources. Lymph from source A proved to be almost inert, lymph B was not much better, but lymph C gave such excellent results that it was at once made the standard supply." It has also been the experience of many people that lymph from the same firm may vary very considerably at different times. For example, samples from a firm of high reputation, which was known to have sent out most excellent material two years ago, have been found, during the present epidemic, not only to have contained more micro-organisms than they should have done, but to have given such poor results that a series of inoculations had to be repeated with another brand, the consequences being such as to leave no doubt that the former samples were practically inert.

If a lymph is inert the cause may be either that it has been kept too long, or that it has been over-diluted, or that it has been obtained from unsatisfactory vesicles. Over-dilution may very possibly have taken place sometimes in the excessive demand caused by the present epidemic. As regards the nature of the vesicles, it is interesting to note that statistics from public institutes are occasionally to be met with exhibiting the number of inoculations performed with lymph from each of a series of calves, and apportioning to each calf the number of failures for which it was responsible. It is instructive to find that the great bulk of the failures generally aggregates about one or two animals out of the series. Then it turns out that there was some slight irregularity noticed about the vesicles of these calves, but it was so slight that it was not considered at the time to be of any moment. Experiences of this sort once more impress upon us the fact that a very slight and temporary aberration on the part of the responsible attendant may make all the difference between a good lymph supply and a bad one. Methods of standardizing lymph do not as yet appear to be thoroughly satisfactory. The proposed rabbit test, mentioned above, is hardly likely to meet with much favour; in fact nothing seems so satisfactory as the test of inoculating a baby, it being of course understood, in dealing with a new lymph before sending it out, that a very careful bacteriological examination has been made to show that the lymph contains nothing of a dangerous nature.

[48] *Lancet*, April 5th, 1902.

The practitioner desires to know not only whether the lymph he purchases will be effective, but also whether it is safe. Some useful light has been thrown upon the question of the bacteriological purity of commercial lymphs by the *Lancet's* investigation, which was published in that journal on April 28th, 1900. Lymph was obtained from thirteen different sources and the extraneous bacteria it contained were investigated. The samples analysed were purchased in the ordinary course of business, with such precautions that the manufacturers who sent them out could have no idea that they were not to be used for ordinary vaccination. The results of the analyses are published in full, each under the title of its respective brand, so that the reader has a free opportunity of forming his own opinion as to their respective merits. In taking a general survey of the evidence thus obtained, the *Lancet* finds that "during the last three years there has certainly been a marked general improvement in the character of the lymph supplied from various sources.....The 'extraneous' bacteria have not yet been brought down to a constant quantity, and very few of the 'brands' examined..... were sterile on all occasions. Certain brands, however, were superior in this respect to others.....In certain instances the process of glycerination had been imperfectly carried out. It may be that the lymph had not been stored sufficiently long after being glycerinated, or, on the other hand, that the mixing had not been sufficiently well carried out, or too small a quantity of glycerine had been used." In a few cases there was evidence of carelessness and uncleanliness in the collection of the lymph—for example, presence of long hairs or a comparatively large number of sporulating and anaërobic organisms. Upon the question as to the significance of the organisms actually present, they say: "We are thoroughly satisfied that, so long as the non-spore-bearing organisms are eliminated and the spore-bearing and anaërobic organisms reduced to a minimum, it is not necessary to send out absolutely sterile lymph. These spore-bearing and anaërobic organisms are, except when the lymph is taken from diseased animals, which should never be the case, entirely innocuous."

Whilst this is a very interesting and useful piece of work which well deserves the attention of the practitioner, the unfortunate part of the matter is that, in many cases at all events, samples from the same firm differ in purity at different times; in fact even during the course of the investigation referred to, the *Lancet* finds that there were very striking differences amongst some of the samples emanating from the same firm. A completely satisfactory guarantee for a uniformity of purity is still an unfulfilled desideratum.

Unsatisfactory Results.

If there is any suspicion that the sample of lymph purchased is inert, its failure with primary cases will soon decide the matter. If, however, the result is an excessive or otherwise atypical reaction, one naturally thinks first of contaminating micro-organisms. In such a case a bacteriological examination of the contents of an unopened tube taken from the same batch as the suspected material could easily be obtained from any reliable laboratory. On most occasions a very brief examination, which would not be an expensive matter, would enable the pathologist to say whether there was any obvious indication such as would render it inadvisable to employ the lymph any further. That is generally all that the practitioner would want. A complete analysis made by a competent bacteriologist would be a much more lengthy and costly proceeding, for which the practitioner would naturally not care to make himself responsible; but it would very rarely be required. In the absence of clinical appearances obviously due to pyogenic organisms, it is quite possible that the bacteriologist's report would not throw any light on the nature of the excessive reaction. This is a question, however, upon which there is a good deal of controversy. The extremists in the advocacy of a bacteriologically sterile lymph are inclined to put down all or most of these undesirable reactions to contamination by bacteria; on the other hand, we find statements to the effect that bacteria have

nothing to do with it, and that sterile lymphs may produce these results when lymphs rich in bacteria do not. The weight of evidence seems certainly to indicate that for many of these cases bacteria are not responsible, although, in view of the high importance of insisting that the lymphs we use shall be as free from bacteria as possible, it is injudicious to allow our controversial zeal to betray us into running into the opposite extreme of asserting that the presence of bacteria may be disregarded.

Excluding bacteria, and on the assumption that the vaccination has been properly performed, that is, that the insertions have not been too long or too close together, what other causes of excessive reaction are to be thought of? Bearing in mind that a certain degree of reaction is an essential part of the process, it is not difficult to recognize that an excess of this phenomenon may be due either to an excessive dose of the virus employed or to an excessive susceptibility on the part of the patient. Since lymphs are not properly standardized, and since the personal factor of susceptibility is, in the present stage of our knowledge, largely indeterminate, the importance of the part which these two influences play in the production of undesirable results cannot be accurately dedermined. It is, however, highly probable that in a large majority of such cases one or other of these influences is the responsible factor. People sometimes accuse the glycerine; it is, however, difficult to see how the very small amount of glycerine which is actually absorbed could, provided it be pure, be held accountable for these effects. Those who believe that it could ought to explain why, when a lymph is found in certain cases to produce an excessive reaction, a large number of cases, inoculated with the same lymph containing the same glycerine, and in the same proportions, fail to exhibit a similar reaction. Perhaps, apart from the explanations already suggested, the inclusion of an undue amount of cell débris in the process of removing the vaccine pulp from the calf has something to do with it. Of course if the lymph is prepared as it ought to be, it ought not to be the case that dried crusts and other material from the surface of the vesicles are included in the material out of which the emulsion is made. But as we cannot always feel assured that sufficient care has been taken in this matter, it is at least possible that some of the cases of undue reaction may be attributable to a neglect of this precaution.

Post-Vaccinal Infections.

The diseases which may follow any open wound provide a very wide subject which, in any comprehensive treatise on surgery, might well occupy a whole volume. Placed in its proper perspective, vaccination is but one out of very many possible lesions in which an open wound is produced; there is nothing exceptional or peculiar about it; like all the rest, it must simply take its chance, the danger of infection being less when anticipated, greater when not. We ought, then, if we wished to study post-vaccinal infections seriously and systematically, to approach the subject from the general standpoint of the conditions known to produce infection in wounds. It is, however, customary to make an arbitrary separation and speak of infections known or thought to follow vaccination as a class by themselves. There is not the least objection to doing so, provided it be clearly recognized that the separation is artificial and made for convenience merely, and provided also that we never overlook the distinction between *post hoc* and *propter hoc*. Even in its restricted aspect the subject is a very wide one, and we must confine ourselves here to a few points of interest.

The most fatal disease which has, in a very few instances, been known to follow vaccination is tetanus. A short time ago the British Medical Journal[49] drew attention to a valuable investigation into the subject by Willson of Philadelphia. In the two articles containing the results of his work[50] is to be found a summary of all the pertinent facts ascertainable about the 52 cases which the author has succeeded in collecting of post-vaccinal tetanus occurring between the years 1839 and 1902. In a careful and obviously unbiased analysis of the conditions under which each case arose, Willson shows that there is no reason to believe that in any one of them were the specific organisms of tetanus contained in the vaccine employed. Generally some obvious explanation is forthcoming, such as contamination of the wound with garden soil, street dust, or material from stables where horses were kept. In other instances the ascertained fact that lymph from the same source, sometimes from the same tube, was productive of no ill-effects upon other persons inoculated indicates that the particular portions of it used for the persons who afterwards developed tetanus are not likely to have been responsible for that disease. As the result of inquiries into the bacteriological evidence available upon the subject, Willson finds that "up to the present time many experiments have been carried out with a view to discovering the presence of the tetanus spores in the vaccine virus, and especially in the glycerinated form ..... In none of the experiments published up to date, however, has success followed the effort to discover the organisms." He himself performed a large number of careful experiments with the object of discovering the tetanus bacillus in suspected lymph, but met with negative results in every case. Moreover, with material stigmatized with this undesirable suspicion, there being no other available, he and his colleagues inoculated 1,600 students, none of whom developed tetanus.

The occurrence of a number of tetanus cases following vaccination, such as the two groups referred to by Willson, the one in Camden, New Jersey, and the other in Philadelphia, does not, within recent memory, appear to have been met with in this country; the reason probably being that tetanus does not happen to have been prevalent in any district at a time when an outbreak of small-pox has led to revaccination on an extensive scale. Two quite isolated cases have been placed upon record this year. The first of them is reported by Drs. W. and J. W. Findlay of Glasgow.[51] A young woman, aged 21, was revaccinated on the outer side of the leg, midway between knee and ankle. Calf lymph as supplied by the Health Office of the City of Glasgow was used, and the following antiseptic precautions were taken: "The middle third of the leg was cleaned with turpentine, and then with methylated spirits, after which the part was again rubbed over with a carbolic solution (1 in 40). The lancet used was always kept in a glass of carbolic solution. A large adhesive thick felt or bunion plaster was then applied around the vaccination mark, and was kept in position by a strip of adhesive plaster." Symptoms of tetanus commenced twelve days after inoculation. As the authors point out, the antiseptic measures adopted, though more than those usually employed by vaccinators, "were, of course, quite inadequate to destroy any spores of the tetanus bacillus lodged about the glands or the pits of the skin." The moral of the case appears to be that, as we can never be certain that street dust may not contain tetanus spores, women who insist upon being vaccinated on the leg run a slight risk that, in the apparently unavoidable road sweeping process which their skirts sometimes perform, they may inoculate themselves with that disease. The second case was referred to at a recent meeting of the Pathological Society of London by Dr. Andrewes.[52] A girl, aged 11 years, "on the eighteenth day after a successful revaccination, developed trismus and risus sardonicus, and died of broncho-pneumonia and respiratory failure four days from the onset of nervous symptoms, without having presented all the classical symptoms of tetanus, though this infection was strongly suspected." From animal experiments made with extracts of the organs obtained *post mortem*, Dr. Andrewes concludes: "As the result of these experiments, I felt no doubt whatever that the patient had died of tetanus."

Of the less rare post-vaccinal complications of a dangerous and infective character, the most frequently discussed is erysipelas. When we consider the enormous number of vaccinations annually performed upon persons of uncleanly habits who live in filthy surroundings, the only matter for surprise is that the vaccination wound does not provide an entrance for the micro-organisms of that disease much more frequently than it is reported as doing. For example, in a recent report issued from the Vaccine Establishment at Lamb's Conduit Street (1899-1900), which is typical of many others, we find that during the year, 2,615 primary vaccinations were performed and 988 revaccinations; of this total number 25 cases were brought back for inspection on account of some abnormality; 21 of these were described as "sore arm," probably due to

[49] May 3rd, 1902, p. 1102.
[50] *Am. Med. Asso.*, May 3rd and May 10th, 1902.
[51] *Lancet*, February 22nd, 1902, p. 506.
[52] British Medical Journal, April 19th, 1902, p. 965.

domestic maltreatment; and as regards the remaining 4, "there were 2 cases of transient eruption and 2 cases were reported to be erysipelas commencing respectively on the fifteenth day and the eleventh day after vaccination." Similarly, in the official annual summary of the reports from the institutes in Germany we find here and there an isolated instance of erysipelas noticed as occurring after vaccination, but the total number of such cases mentioned is surprisingly few.

A consideration of the many other skin diseases which have been noted as occurring after vaccination would form a large subject; it can only be remarked here that if we eliminate personal idiosyncrasy and predisposition and the ordinary possibilities of various extraneous organisms finding their way into a wound, there seems to be remarkably little left for which vaccination, as such, can be justly held accountable.

Antiseptic Precautions.

Upon the question as to what antiseptic precautions the vaccinator ought to take in performing his operation, and in the subsequent treatment of the wound, there is every variety of opinion. At the one extreme we have those who hold that the treatment ought to be conducted with all the rigidity of asepsis which characterizes an important surgical operation; at the other end of the scale are those who believe that, provided we have good lymph and a clean instrument, we need not trouble about any danger of extraneous contamination; and then there is a large intermediary class who find contentment in the elasticity of the phrase, "with all precautions possible."

Ideally speaking, the routine would be—make the inoculation site absolutely sterile; remove all traces of disinfectant with sterilized water or absolute alcohol; apply aseptic dressings after the operation so as to exclude the entrance of extraneous organisms; and in the stage of discharge keep the dressings clean by constant renewal.

It is not part of the purpose of the present article to consider how many vaccinators actually adhere to such rules as these, or how far others may deviate from them. They are better entitled to speak for themselves on that matter. But there are certain possible difficulties which may be pointed out as apparently standing in the way of strict asepsis. There is, in the first place, the question of time. The waiting room may be crowded with patients waiting to be vaccinated, and the operator may know that he ought to work at the rate of about thirty an hour in order to get through his daily task. In such a case, unless he has several attendants to do the cleansing for him, it must be very difficult to adhere to the principles of strict aseptic surgery. Again, his subsequent inspection of the patient will probably be limited to a single visit a week later, which seems hardly enough to satisfy the requirements of the aseptic theory of treatment. Supposing the arm to be really sterile at the time of inoculation, a clean dressing carefully applied ought to be a satisfactory protection for some days. But if there are numerous bacteria left at the site of inoculation, the additional warmth of the protective covering applied will probably only tend to foster their growth. Again, in the stage of discharge, if the dressing as soon as it becomes soaked is replaced by a clean one, well and good; but if it is left on until it becomes purulent and filthy, it will simply degenerate into a bacterial hotbed, and, as by this time it has probably worked loose, bacteria from outside will make their way in, and will find in this unpleasant mess greater facility for luxuriant growth than if the wound were unprotected. It must thus be a very difficult task for the vaccinator who insists on the importance of thorough asepsis always to carry out his treatment to his own satisfaction.

With regard to the view that cleansing of the arm and protective dressings are unnecessary, the practical consequences of disregarding such precautions will probably vary with the class of patient dealt with. With a patient of thoroughly cleanly habits the chances of any harm resulting are, no doubt, very slight indeed; but with a careless subject, and still more with a person engaged in a dirty or dusty occupation, the risk is certainly appreciable.

The intermediate principle of taking "all precautions possible" may perhaps be interpreted as meaning that the methods adopted must be adjusted to the condition of the patient. Thus we may imagine that the amount of cleansing performed will vary according to circumstances, from the application of warm water merely to soap and water, alcohol, carbolic acid, and finally to thorough surgical sterilization, and that, though protective dressings will be applied or ordered when thought desirable, they will not, as a matter of routine, be sealed down with strapping, with strict injunctions that, filthy or not filthy, the patient must on no account disturb them for a week.

From a survey of the possible contingencies we have mentioned, it appears to follow that in the general question of vaccination asepsis there is great scope for individuality of judgement.

THE VACCINATION HISTORY OF SMALL-POX CASES.

THE importance of obtaining all the facts available as to the condition of a small-pox patient in respect of antecedent vaccination will be generally admitted. The differences which exist between the well vaccinated, the indifferently vaccinated, and the unvaccinated in liability to small-pox attack, and in severity of the disease if contracted, have long been established on a larger and firmer statistical basis than almost any other facts in medicine. Nevertheless, continued observation and record are clearly still essential, not only to control conclusions drawn from earlier and larger data, but also as a means of adding to knowledge on a number of important points of detail. Investigation of such questions as the duration of protection afforded by vaccination at one or another age; the extent to which security depends upon the area of vesiculation produced by vaccination; or the significance, *quâ* protection, to be attached to the presence or absence of revaccination scars, is essentially an affair of figures, and it is needless to point out that the larger the total number of observations available the better the opportunity of drawing correct inferences.

It is now generally understood that the mere statement that a case of small-pox is "vaccinated" or "unvaccinated" has no value for statistical purposes. Classification of small-pox deaths in this way has now very properly been abandoned at the Registrar-General's office. "Vaccinated," for example, may or may not mean that evidence of vaccination rests on the presence of a vaccination cicatrix, while the term has not infrequently been applied, without qualification, to cases vaccinated for the first time when incubating small-pox. Such cases for statistical purposes ought clearly to be kept in a class by themselves.

At the small pox hospitals of the Metropolitan Asylums Board at Long Reach it has been the practice of the medical staff for many years to devote much care to the systematic collection vaccination data. The following are the particulars sought on admission in each case, and recorded along with notes of the patient's age, dates of admission and discharge (or death), and type of disease:

Statement Made as to Primary Vaccination: for example:

Stated to have been vaccinated.
Not stated to have been vaccinated.
Stated to be unvaccinated.
Primary vaccination performed only after infection by small-pox.

Statement as to Revaccination, or as to Previous Attack of Small-pox: for example:

Stated to have been successfully revaccinated; if so, how long ago?
Stated to have previously suffered from small-pox; if so, how long ago?
Revaccinated only after infection by small-pox; if so, when?

Vaccination Cicatrices.

Total number.
Their collective area in terms of a square inch.
Fractions of cicatricial area which can be described as foveated.
Other observations regarding cicatrices.
Nature of evidence of revaccination afforded by cicatrices or otherwise.

Marks of Successful (Primary or Re-) Vaccination Performed after the Case had been Infected by Small-pox.

Their total number.

The greater portion of the data thus obtained are classified year by year in the elaborate series of vaccination tables which appear in the annual report of the Statistical Committee of the Metropolitan Asylums Board, and it is probable that in future additions will be made to these tables so as to allow certain other of the points above detailed to be exhibited in statistical form.

At provincial small-pox hospitals the practice of recording vaccination observations varies considerably. Not infrequently, owing to the stress of emergency arrangements necessary to provide hospital accommodation for small-pox cases, such records are imperfectly kept.

It is particularly desirable that the facts as to vaccination of small-pox cases should be able to be ascertained for the country as a whole, but for this to be done it is clearly essential that they should be noted in the same way at all provincial hospitals, whether large or small, temporary or permanent.

We understand that a timely proposal has been made that the Local Government Board should issue a form of vaccination register for use at all small-pox hospitals other than those of the Metropolitan Asylums Board. It is suggested that this register should be compiled from special "vaccination cards" filled up for each patient at the time of admission. From these cards, or from the register, the vaccination history of each patient can be seen at a glance. The following are the sub-divisions proposed:

Patient's name. Age. Address. Date of Admission to Hospital. Type of Disease. Date of Discharge. If fatal, Date of Death.

Class A.

If presenting a vaccination cicatrix or cicatrices ... ...
- Their number.
- Their approximate total area in terms of a square inch.
- Age at vaccination.

Class B.

If presenting no vaccination cicatrix or cicatrices* ... ...
- Stated to have been vaccinated.
- Not stated to have been vaccinated.
- Known to be unvaccinated.

* Note to Class B.—Cases in which it is doubtful whether a scar or scars on the usual sites of vaccination can be referred to vaccination, and also cases in which scars affirmed to be present are obscured by copious eruption, should be placed in Class A, but an explanatory note should be added.

Class C.

If presenting no vaccination cicatrix or cicatrices, but showing marks of vaccination performed subsequent to the case having been infected by small-pox ...
- Date of such vaccination.
- Date of appearance of eruption of small-pox.

Class D.

If stated to have been successfully revaccinated ... ...
- Are cicatrices present which may be attributed to revaccination?
- How long since last successful revaccination?
- Was the revaccination performed after the case had been infected by small-pox?

Class E.

If stated to have previously suffered from small-pox ... ...
- Are scars present which may be attributed to previous small-pox?
- How long since previous attack of small-pox?

The system here proposed has the additional advantage of facilitating the observance of Section VIII of the Vaccination Act, 1898, which requires the keeping of a "list of names, addresses, ages, and condition as to vaccination of all small-pox patients" treated at a hospital maintained by any sanitary authority. By the same section these lists are made accessible, under certain restrictions, to the public, and for this reason also is important that they should not lack completeness.

The following are a few points which may be noted in connexion with vaccination records.

Patients' statements with regard to primary vaccination should be carefully ascertained wherever no vaccination marks are observed. In the case of children inquiry should be made of the parents. It must be remembered, however, that the reliance which can be placed on such statements is often small. The statement of an adult that he is vaccinated may be a mere assumption, or be based on an imperfect recollection of what he has been told by his parents. The uncertainty is illustrated by the not infrequent cases in which an adult will confidently assert that he is unvaccinated, notwithstanding that unmistakeable vaccination scars can be found on his arm. Parents again are sometimes led to assert—contrary to fact—that their child has been vaccinated, through apprehension that proceedings may be taken against them if they admit their neglect.

Patients' statements with regard to revaccination are of special importance, as the test afforded by the presence or absence of scars is here far less conclusive than in the case of primary vaccination. The age at revaccination, and the reason which the patient furnishes for concluding that the operation was successful should be inquired into.

Vaccination scars should preferably be looked for by daylight, but it is well to remember that faint scars are liable to escape observation if the arm is in too strong a light. With ordinary care, however, the presence of vaccination scars can very seldom be missed. The rare cases in which vaccination is performed in some unusual position—for example, on a naevus*—are worth bearing in mind. Cases occasionally arise where assertion that vaccination scars are absent is impossible: for example, a patient with extensive scars on the arm from a burn. The eruption of small-pox, even in a severe case, is very seldom so extensive on the upper arms as to interfere with observation of scars. And, as Dr. Ricketts has pointed out, proper observations may be made even when the rash is thick in this situation, provided the eruption is not far advanced. It will be noted that in the vaccination classification above referred to, it is suggested that vaccination should not be given the benefit of the doubt in cases where scars affirmed to be present cannot be observed for reasons such as those just given.

To obtain the approximate total area of scars in terms of a square inch, it is necessary to reckon the size of each separate scar. At the Metropolitan Asylums Board hospitals, the area in the case of scars of an ordinary character is ascertained by taking a longitudinal and transverse measurement of each scar by means of a scale, and obtaining the area of a corresponding ellipse from a specially prepared table. A more ready, if slightly less exact, method is to compare the scar with a series of circles of known area, which can be kept at the hospital for reference. The area of a threepenny-piece slightly exceeds $\frac{1}{4}$ square inch; that of a sixpence is about $\frac{1}{6}$ square inch. At the Metropolitan Asylums Board hospitals it is usual to make separate note of puckered scars, the area of which has clearly been determined by exceptional inflammatory action supervening on the vesiculation of vaccinia.

The significance of the foveation of scars as an index of satisfactory vaccination has been frequently insisted on, and it will be interesting to observe how far foveation continues to characterize the scars which result from vaccination with glycerinated calf lymph as at present practised. Observations of foveation, however, depend far more upon the judgement of the observer than the estimation of scar area; and trustworthy conclusions can be drawn only from large series of cases observed by a limited number of individuals following precisely the same system. Such opportunities would seldom arise in the smaller small-pox hospitals of the country.

At the present day the large majority of small-pox cases are removed to isolation hospitals, and it is there that such observations as are dealt with in this article should in most instances be made. But some districts do not possess isolation accommodation for small-pox; moreover, some severe and rapidly fatal cases of small-pox are too ill to be moved to hospital. The latter cases are necessarily of first importance from the statistical viewpoint, and we would strongly urge upon all medical practitioners called to cases of this kind themselves to obtain and note at the earliest opportunity as many of the details of vaccination history as are available. Such observations are not only of much service to the medical officer of health of the district, but they have the great advantage of enabling the Registrar-General to broaden the basis on which to classify fatal cases of small-pox in accordance with their vaccination history.

* The late Dr. Cory, it will be remembered, when vaccinating on a naevus adopted the useful plan of making at the same time a single insertion of vaccine on the arm.

SANITATION OR VACCINATION.

IN endeavouring to explain away the manifold proofs that vaccination prevents small-pox, perhaps no line is now so frequently followed by antivaccinationists as that which attributes to sanitation all the good effects of vaccination. Medical men are well aware that any assertion of this sort is fallacious, but they are not always able to produce evidence of the fallacy, and it may be convenient to call attention briefly to facts which prove the worthlessness of the antivaccinationist contention.

Sanitation is a term of varied meaning. A man with a clean skin, eating clean food, drinking clean water, breathing pure air, taking proper exercise and proper rest, is in a better position to resist disease of any kind, including small-pox, than another man living under the opposite conditions. But the same special sanitary measures which are powerful against one disease are not necessarily effective against another. The means which control enteric fever are not at all identical with those which have so greatly diminished typhus; and measles and whooping-cough are not to be fought with the weapons which are selected in the case of diphtheria or diarrhoea. Similar considerations apply to small-pox prevention. That disease is not known to have any special relationship to water supply or milk supply, or sewage, or soil pollution. In so far as overcrowding enables the infection to be carried more readily from individual to individual, the prevention of overcrowding is a sanitary measure of value against small-pox, but the distance through which small-pox can be transmitted is so much greater than in the case of typhus, that the same results from prevention of overcrowding cannot be looked for in the two cases, and experience proves that as a matter of fact they have not been obtained. The value of sanitation is so abundantly proved in many directions that it is quite unnecessary for even its most enthusiastic advocates to resort to any doubtful tactics for its promotion—tactics which would give sanitation the credit for results which are clearly due to vaccination.

Much of what is set down here has already been pointed out in the BRITISH MEDICAL JOURNAL or elsewhere, but it is desirable to restate the case with special reference to the one question of sanitation.

1. *Vaccination Without Sanitation.*

The City of Glasgow in its experience of small-pox a century ago proved that vaccination in the entire absence of sanitation had an immediate and direct effect in reducing the prevalence of small-pox. The population of Glasgow increased very rapidly from about 1780 onwards. In that year it was 42,832. In 1791 it was 66,578; in 1801 it was 83,000; in 1811 it was 110,000, and in 1831 it was 202,000. The area occupied was very small, the people living layer upon layer in high tenement houses closely built together. Reports made in 1818, 1837, 1838, etc., show its sanitary condition to have been extraordinarily bad—perhaps worse than that of any other large town in Britain. Before vaccination was practised, 19 deaths were due to small-pox in every 100 deaths from all causes. Under vaccination the 19 were reduced in six years to less than 9, and in other six years to less than 4. At the same time, whooping-cough became more prevalent and measles increased enormously. There was no disinfection and no isolation in hospital, and there was still quite sufficient small-pox in the town to give opportunity for the infection of every person susceptible to that disease. But as a matter of fact in Glasgow, with sanitation going from bad to worse, with the population increasing as above shown, with measles deaths multiplying, small-pox in presence of vaccination diminished by leaps and bounds.[1]

2. *Small pox, Measles, and Whooping cough.*

In prevaccination times, small-pox, measles, and whooping-cough were the principal infectious diseases of early childhood. From about 90 to 98 per cent. of all small-pox deaths were in children under 10 years of age, and the large majority were under 5 years of age. Since vaccination began small-pox has in great measure departed from childhood, and has transferred itself to later years. Measles and whooping-cough, on the other hand, are still diseases of childhood as they were before. Sanitation cannot possibly explain this difference between small-pox on the one hand and measles and whooping-cough on the other. The practice of vaccination at once gives the necessary explanation.

[1] See Jenner Number of *Public Health*, May, 1896.

3. *Small-pox Age-Incidence in the Vaccinated and Unvaccinated.*

Among the vaccinated, small-pox, as has just been said, has largely transferred itself from childhood to later life, but among the unvaccinated it still largely prevails among children, though, owing to the comparative infrequency of epidemics in fairly vaccinated populations, the unvaccinated have not, as a rule, so early an opportunity of infection as of old. Sanitation cannot account for small-pox among the unvaccinated finding so large a percentage of its victims among children, while in the vaccinated it attacks a much less proportion of children than of adults.

4. *Small-pox Age-Incidence in Scotland.*

It has been suggested that sanitation has a specially beneficial effect on the young, and that this would account for the altered age-incidence of small-pox, but it has already been pointed out that the age-incidence of measles and whooping-cough has not been altered, and that among the unvaccinated small-pox is still in great measure a disease of childhood. In addition the following may be noted.

In Scotland the vaccination age is 6 months. If sanitation be the cause of the diminished share of small-pox borne by children, that diminution will appear from the beginning of life. If, on the other hand, vaccination be the cause, the fall will show itself only from the age of 6 months. The Scottish Vaccination Act dates from 1863. In the nine previous years, 1855-1863, the children under 6 months contributed 139 of every 1,000 small-pox deaths at all ages. In the twenty-four years subsequent to the Act they contributed 138 of every 1,000 small-pox deaths at all ages. The proportion is thus seen to be practically unchanged. At six months of age vaccination comes in. In the nine years prior to the Act the second half year of life contributed 153 of every 1,000 small-pox deaths. In the twenty-four years subsequent to the Act it contributed only 47 of every 1,000 small-pox deaths. It was vaccination not sanitation which altered the age-incidence.

5. *Small-pox Age-Incidence in Germany.*

In Germany both vaccination and revaccination are compulsory, and small-pox has greatly diminished, but antivaccinationists in this country attribute the diminution to sanitation. In Germany primary vaccination is not compulsory before the end of the calendar year following the birth of the child, that is, any time between the age of 12 months and 24 months. Thus the first two years of life are not under any compulsory law of vaccination. In Germany in 1886-90, of 735 small-pox deaths at all ages, no fewer than 301 were under 2 years of age. It is the want of vaccination not of sanitation that accounts for this remarkably great share of small-pox borne by babies in Germany.

6. *Small-pox Age-Incidence in Sheffield, Leicester, Warrington, and Gloucester.*

When small-pox came to Sheffield in 1887-8 the town was well vaccinated so far as primary vaccination is concerned. When it came to Leicester it was ill-vaccinated. It is said by opponents of vaccination that Sheffield was an insanitary town and Leicester a sanitary town. But in Sheffield the children under 10 contributed less than 26 per cent. of the total small-pox deaths, while in Leicester in 1892-3 they contributed about 70 per cent. In Warrington there was very little default in primary vaccination, and the children under 10 contributed only 22.5 per cent. to its total small-pox cases. In Gloucester, on the contrary, vaccination was much neglected, and the children under 10 contributed 64.5 per cent. of its total small-pox cases. It was vaccination, not sanitation, that made the difference. Before the Gloucester epidemic came, the Secretary to its Antivaccination League told the Royal Commission that Gloucester was a very sanitary town, and its freedom from small-pox at that time was attributed to sanitation. But small-pox came shortly afterwards, and the town had a terrible epidemic. Ever since then the antivaccinationists' explanation has been that Gloucester was a very insanitary town.

7. *Small-pox in "Healthy Districts."*

It has been pointed out that in what the Registrar-General calls Healthy Districts small-pox prevails less than in the rest of England, and it has been argued that sanitation makes the difference. But a Healthy District, according to the Registrar-General, simply means a place with a crude death-rate not exceeding 15 per 1,000 per annum. Practically all such districts are very sparsely populated rural localities. There is less opportunity for the spread of infection from person to person because the average distance between person and person is very great, and instead of large cities or towns there are merely villages or hamlets or single houses. Such places, however, are often most defective in their sanitation. The houses are often very damp, the drainage and water supply often very bad, and there is usually no organized system of refuse removal. Yet, under these very insanitary conditions there is a low general death rate, and little small-pox, and that disease finds a footing so seldom that the average age-incidence of small-pox is higher than in towns. Sanitary effort is not responsible for the differences, but only the fact that the people live very far from each other, and that the air is purer, and that infection is more difficult to carry.

8. *Small-pox Attack-Rates in the Vaccinated and Unvaccinated.*

As shown elsewhere in this issue of the Journal the attack-rates of small-pox are much higher among the unvaccinated than among the vaccinated. Sanitation cannot account for this difference. It is observed in populations like Gloucester and Leicester, where vaccination is much neglected and where the vaccinated and the unvaccinated live under the same sanitary or insanitary conditions, belong to the same classes of the community, and are similar in house accommodation, and have the same water supply, sewerage, refuse removal, and all other things which make up the sanitary administration of a town.

The difference between the attack-rate in the vaccinated and the unvaccinated is specially great in children under ten years. It is part of the modern doctrine of vaccination that its protective power diminishes as the length of time increases from the performance of the protective operation. This diminution shows itself in a drift back towards susceptibility to *attack* by small-pox. Ultimately the protection against *death* by small-pox also diminishes among the vaccinated, though not to the same extent as protection against attack. Sanitation cannot account for this special difference between the attack-rates of vaccinated and unvaccinated children as compared with the lesser difference between once-vaccinated and unvaccinated adults.

9. *Small-pox Fatality-Rates in the Vaccinated and Unvaccinated.*

In the report of the Royal Commission on Vaccination and in the present issue of the British Medical Journal and in many works on the subject superabundant evidence is produced that the fatality (or case mortality) rate of small-pox is much less in the vaccinated than in the unvaccinated. Sanitation cannot possibly account for this difference.

It has sometimes been urged that the unvaccinated belong to a class of the community whose members and especially whose children would succumb more readily than the vaccinated to any disease which might attack them. This argument was more frequently adduced twenty years ago, before anti-vaccination had spread in towns like Gloucester, Leicester, and Dewsbury, etc., to such an extent as to provide the obvious reply. In these places omission to vaccinate has been the rule and not the exception, and in some of them neglect of vaccination has been almost universal in recent years. In Leicester and Gloucester, for example, there can be be no practical distinction between the social condition or general health of the vaccinated and the unvaccinated. Indeed, it is a favourite contention of antivaccinationists that the vaccinal operation injures the general health and lowers vitality, at the same time that it gives no protection against small-pox. If so, the unvaccinated in Leicester and Gloucester should have a lower fatality-rate from small-pox than the vaccinated in the same towns respectively. But instead their fatality-rate is much higher. It is vaccination, not sanitation, that makes the difference.

Similarly, it has been urged that the unvaccinated are made up more or less of children whose vaccination has been medically postponed owing to ill-health, but in places like Gloucester and Leicester where non-vaccination is so general this contention also is of no validity. Even in well vaccinated towns it has no real weight. Postponements are usually made only for a very short period and may not be due to debilitating diseases or to any conditions which would result in excessive fatality from small-pox.

It is also said that the unvaccinated include babies under 3 or 6 months old whose legal time for compulsory vaccination has not arrived; but, again, in antivaccination centres like Gloucester and Leicester, the unvaccinated include all ages; while in better protected places, if small-pox deaths under one year of age, whether in the vaccinated or the unvaccinated, be omitted from the calculation, they make no practical diminution of the striking difference which exists in the fatality rates as between the two classes.

10. *Small-pox Incidence in Invaded Houses.*

In a number of recent epidemics of small-pox beginning with that of Sheffield in 1887-8 and including epidemics at Leicester, Gloucester, Dewsbury, Warrington, and London, careful records were made of the behaviour of small-pox towards the vaccinated and the unvaccinated members respectively of households actually infected with the disease. The comparison between the attack-rates of the total vaccinated and unvaccinated population of these households shows a very great and striking difference in favour of the vaccinated. Sanitation cannot possibly account for this. The persons are members of the same households, living under the same municipal and domestic conditions of cleanliness, ventilation, air space, and so forth, eating the same food, drinking the same water, attending the same schools, and engaged in the same occupations. The only difference between them is that some are vaccinated and some are not, and small-pox selects its victims in very much greater proportion from among the unvaccinated than from among the vaccinated.

11. *Efficient and Inefficient Vaccination.*

Statistics of small-pox hospitals as given in the Report of the Royal Commission, show that children with three or four vaccination marks have a distinctly less fatality-rate from small-pox than children with only one or two vaccination marks. Similarly it is shown that children, the total of area of whose vaccination marks exceeds half a square inch, have a lower fatality-rate when attacked by small-pox than children the total area of whose marks is less. This difference cannot possibly be accounted for by sanitation.

12. *Small-pox in the Postal and Police Services.*

In towns where small-pox epidemics have occurred the members of the postal and police services have usually been revaccinated. The revaccinated police have attended to their duties in the slums of stricken towns, and postmen have gone about from door to door making their daily rounds in infected districts. They have not been attacked by small-pox. How could sanitation, say in their own dwellings, protect them during their work in the slums?

13. *Small-pox amongst Hospital Nurses.*

In small-pox hospitals nearly all the nurses and other members of the staff are revaccinated before beginning duty. Occasionally, however, revaccination has been omitted, and so the materials exist for a control experiment. The hundreds or thousands of revaccinated nurses in the small-pox hospitals have escaped the disease though living and breathing in an atmosphere pervaded with small-pox poison. On the other hand the few nurses and attendants attacked by small-pox had not been revaccinated. In Leicester the total staff was 40. Six of the 40 refused revaccination. Five of the 6 were attacked and 1 died. Of the other 34, 1 whose revaccination was about ten years old, had a very slight attack. The others escaped, the majority having been revaccinated and the rest having had small-pox previously. Sanitation cannot possibly account for these differences. Diseases like typhus fever, diphtheria, and scarlet fever spread freely among hospital nurses not immune through previous attack.

FINAL REPORT OF THE ROYAL COMMISSION APPOINTED TO INQUIRE INTO THE SUBJECT OF VACCINATION.

SINCE the Jenner Number of the BRITISH MEDICAL JOURNAL was issued on May 23rd, 1896, the Final Report of the Vaccination Commission has been published, and a Vaccination Number of the JOURNAL would be incomplete without some account of its contents.

The Royal Commission on Vaccination was appointed on May 29th, 1889, and issued its Final Report in August, 1896. Its membership consisted originally of Lord Herschell, the Chairman; Judge Meadows White, Q.C.; Mr. John S. Dugdale, Q.C.; Sir Edward Galsworthy, Chairman of the Metropolitan Asylums Board; Sir Charles Dalrymple, M.P.; Mr. Samuel Whitbread, M.P.; Mr. Charles Bradlaugh, M.P.; Mr. J. A. Picton, ex-M.P.; and the following members of the medical profession: Sir James Paget, Bart., Sir Wm. S. Savory, Bart.; Sir W. Guyer Hunter, ex-M.P.; Professor Michael Foster, Dr. J. S. Bristowe, Dr. W. J. Collins, and Mr. Jonathan Hutchinson. In consequence of the death of Mr. Bradlaugh, Mr. John Albert Bright, M.P., was appointed on April 18th, 1891. Before the Commission had concluded its sittings, Sir William Savory and Dr. Bristowe died, and their places were not filled. Lord Herschell, Sir James Paget, and Sir W. Guyer Hunter are now also dead.

The questions submitted to the Commission were as follow:—

1. The effect of vaccination in reducing the prevalence of and mortality from small-pox.
2. What means, other than vaccination, can be used for diminishing the prevalence of small-pox; and how far such means could be relied on in place of vaccination.
3. The objections made to vaccination on the ground of injurious effects alleged to result therefrom, and the nature and extent of any injurious effects which do, in fact, so result.
4. Whether any, and, if so, what means should be adopted for preventing or lessening the ill-effects, if any, resulting from vaccination; and whether, and if so by what means, vaccination with animal vaccine should be further facilitated as a part of public vaccination.
5. Whether any alterations should be made in the arrangements and proceedings for securing the performance of vaccination, and in particular in the provisions of the Vaccination Acts with respect to prosecutions for non-compliance with the law.

In the course of the seven years between their appointment and report the Commission heard 187 witnesses, of whom the great majority were put forward to represent the case for antivaccination. The Commission also appointed certain medical men to make inquiry into alleged cases of vaccinal injury and into certain outbreaks of small-pox that occurred in England in the course of the seven years. The medical men so appointed were Dr. Sidney Coupland, Dr. Theodore Dyke Acland, Dr. A. P. Luff, Dr. T. D. Savill, and Dr. Thomas Barlow. The results of the labours of the Commission are recorded in seven Reports and nine appendices. Some of these appendices consist of separate volumes. The Final Report is signed by eleven of the thirteen members of the Commission then alive. Two of the eleven—namely, Sir Guyer Hunter and Mr. Jonathan Hutchinson—append a note recording their opinion that revaccination at the age of 12 should be made compulsory. Two others—namely, Mr. Whitbread and Mr. John Albert Bright—while agreeing with the other signatories to the report as to the value and necessity and safety of vaccination, are of opinion that even modified compulsion is unnecessary and impracticable. In this last view they are joined by Dr. Collins and Mr. Picton, whose whole Dissent from the Report is recorded in a Statement printed in the volume containing the Final Report.

THE CONCLUSIONS.

The conclusions as to the value of vaccination in relation to small-pox arrived at by the Commission are as follows:

We think:

1. That it diminishes the liability to be attacked by the disease.
2. That it modifies the character of the disease, and renders it (*a*) less fatal, and (*b*) of a milder or less severe type.
3. That the protection it affords against attacks of the disease is greatest during the years immediately succeeding the operation of vaccination. It is impossible to fix with precision the length of this period of highest protection. Though not in all cases the same, if a period is to be fixed, it might, we think, fairly be said to cover in general a period of nine or ten years.
4. That after the lapse of the period of highest protective potency the efficacy of vaccination to protect against attack rapidly diminishes, but that it is still considerable in the next quinquennium, and possibly never altogether ceases.
5. That its power to modify the character of the disease is also greatest in the period in which its power to protect from attack is greatest, but that its power thus to modify the disease does not diminish as rapidly as its protective influence against attacks, and its efficacy during the later periods of life to modify the disease is still very considerable.
6. That revaccination restores the protection which lapse of time has diminished, but the evidence shows that this protection again diminishes, and that to insure the highest protection which vaccination can give the operation should be at intervals repeated.
7. That the beneficial effects of vaccination are most experienced by those in whose case it has been most thorough. We think it may fairly be concluded that where the vaccine matter is inserted in three or four places it is more effectual than when introduced into one or two places only; and that if the vaccination marks are of an area of half a square inch, they indicate a better state of protection than if their area be at all considerably below this.

SUMMARY OF REPORT.

It is not our purpose to give an account of the contents of any but the Final Report, and even it can only very partially be summarized in the space available. The Report is a rich storehouse of information, and our summary will deal chiefly with the parts a knowledge of which is most likely to be of interest and value to the medical profession.

THE EFFECT OF VACCINATION IN REDUCING THE PREVALENCE OF AND MORTALITY FROM SMALL-POX.

At the close of the eighteenth century, or earlier, there was a belief in dairy districts that people who had taken cow-pox never took small-pox, and in 1774 a Dorsetshire farmer, Benjamin Jesty, inoculated his wife and sons with cow-pox to protect them from small-pox. But the practice of vaccination really dated from the publication of Edward Jenner's *Inquiry into the Causes and Effects of the Variolae Vaccinae* in 1798.

The Beginnings of Vaccination.

The report gives an account of the earliest days of vaccination, including questions which arose between Jenner and Woodville and Pearson as to the general eruption following some cases of so-called vaccination. The subject of the variolous test, as used in appraising the protection conferred by vaccination, is considered in a very well-written Appendix. These matters, however, were dealt with in a special article in the Jenner Number of the BRITISH MEDICAL JOURNAL, and cannot be reverted to here at any length. The Commission hold that the medical profession at the close of the eighteenth century had had a very considerable experience of the practice of small-pox inoculation, and of its varying effects under different circumstances, and that there is no reason whatever to think their mental attitude different when using inoculation as a test of insusceptibility to small-pox from the attitude adopted when using it as an operation intended to provoke that disease. As concerns the varieties of vaccine lymph that came into use in the early days, "It is clear," the Commission say, "that no contrast as regards the immunity afforded was presented between the cases where one lymph was used and those in which another was employed." Within a short time Woodville's error as to pustular cases in his hospital practice was recognized, and inoculated cow-pox was generally acknowledged to be clearly distinguished from inoculated small-pox in being non-contagious, and, as a rule, unaccompanied by a pustular eruption.

In the year 1800 many leading physicians and surgeons in London signed a declaration in favour of cow-pox, and in 1802 a Committee of the House of Commons reported similarly after hearing a number of experienced witnesses. Again in 1807 the Royal College of Physicians made a report to the House of Commons of an Inquiry into Vaccination. Their inquiry appeared a thorough one. Information was obtained of the results of several hundred thousand cases, and the conclusion was that vaccination was a powerful protection against attack by small-pox, and that in almost every case where small-pox had succeeded vaccination the disease had been remarkably mild.

The Spread of Vaccination.

The practice spread rapidly in Europe and in the New World, and many strains of lymph came into use. In England there are no exact statistical data for the first quarter of the nineteenth century, but the operation was largely practised. In Cambridge in 1824, 48.7 per cent. of the inhabitants under 25 years had been vaccinated, and there is no reason to think it was an exceptional town. The Cambridge figures receive some general support from others relating to London and Norwich. In Sweden, vaccination was introduced in 1801, and its omission became punishable by fine in 1816. The practice of vaccination was very prevalent, from one-third to two-thirds of the children born being operated on. In Denmark compulsion began as early as 1810, and the vaccinations nearly equalled the births in number.

Small-pox in Prevaccination Times.

As a preliminary to the question whether the history of small-pox mortality in the period 1800 to 1825 warrants belief in the protective power of vaccination, there is given some account of the prevalence of small-pox in prevaccination times. It was very prevalent in Western Europe in the whole of the eighteenth century. The London Bills of Mortality afford valuable data from 1629 onwards, and show that the mortality was very high. They give no information about attack-rates or fatality, but they prove that the share of all deaths borne by small-pox was very great in the seventeenth and eighteenth centuries. In Chester in 1774, in a population of 14,713, there were 1,202 cases of small-pox, of which 202 were fatal. At the beginning of 1775 only 7 per cent. of the population of Chester had not had small-pox at some period or other. In Ware, in 1722, the population was 2,515 at the beginning of an epidemic. Of these, 1,601 had already had small-pox, leaving 914 possible victims. Among the 914 there were during the epidemic 612 cases with 72 deaths, leaving 302 persons who are spoken of in the records as "to have the small-pox." There is no reason to think that Chester and Ware are exceptional, but in some small rural parishes in Kent the disease was little known, and no doubt it prevailed less in country districts than in towns. In the provinces it had a more distinctly epidemic character than in London, severe outbreaks occurring every few years, with only few cases in the intervals. In some foreign countries records of small-pox mortality exist previous to the nineteenth century, as in Sweden from 1774, and in Geneva from 1580, and in Copenhagen. Such records confirm the conclusion as to the great prevalence and high mortality from small-pox in Western Europe during the eighteenth century and earlier. The common knowledge of this fact is incidentally illustrated in various ways. Daniel Bernouilli, the distinguished mathematician, writing in 1765, takes as the basis of certain calculations the datum that small-pox carries off the thirteenth or fourteenth part of each generation. Haygarth states that the proportion of mankind incapable of infection by small-pox has been observed to be 1 in 20.

The Fatality of Prevaccination Small-pox.

The case-mortality or fatality-rates in prevaccination times are next considered. Certain statistics collected by Dr. Jurin gave a fatality of 16.5 per cent., but the items making up this rate range from 10 to 36 per cent. The Commission might also have noted that Jurin's figures refer only to a few years between 1720 and 1730. Bernouilli says that the fatality may be as high as 1 in 3, or as low as 1 in 40. The London Small-pox Hospital from 1746 to 1763 showed a fatality-rate of 25.3 per cent., and in the last 45 years of the eighteenth century it is stated to have been 32 per cent. In Warrington in 1773, of 29 persons attacked, 12 died (41.3 per cent.); and the Rev. J. Aikin, who gave Dr. Percival this datum, stated that in other neighbourhoods the fatality was greater, and that he had reason to believe that it was not less on the whole. The Commission therefore, very properly, refuse to state any average fatality-rate, but think it important to bear in mind that it differed widely on different occasions.

Age-incidence of Prevaccination Small-pox.

As regards age-incidence in prevaccination times, all the records in which the necessary information is given bring out the striking fact that a large proportion of the small-pox deaths was contributed by the very young. In Chester in 1774 every one of the 202 fatal cases was under 10 years of age, and a-quarter of them were under 1 year. In Warrington in 1773 all were under 9 years. In Kilmarnock between 1728 and 1763, in 622 deaths the ages of 613 are given, and only 7 of these were above 10. In Edinburgh, 1764-83, of every thousand small-pox deaths, 993 were under 10 years of age. Geneva between 1580 and 1760, and Sweden from 1774 to 1800, show the same feature. Haygarth says that in Chester in 1772-1777, among children under 10, "half as many die of the small-pox as of all other diseases," and Bernouilli assumes this character of small-pox in his calculations.

Small-pox and Vaccination, 1800-1825.

From these data the Commission set up a rough eighteenth-century standard for comparison with later periods, and they proceed to the first quarter of the nineteenth century in order to note the difference. Their reason for fixing on a quarter of a century is stated as being that it constitutes a convenient epoch, and not because the close of that quarter was in any respect a dividing line, for, as a matter of fact, a new epoch more properly began in 1837, when the present system of death registration commenced in England. There is, however, one good reason which might have been stated for dealing specially with the first twenty-five years of the nineteenth century. It was a period during which the question of revaccination could not arise in any prominent fashion. The great bulk of the people of England who were alive at the end of the eighteenth century had already had small-pox, either naturally or by inoculation. Small-pox inoculation also did not die out at the beginning of the century, and as to vaccination, the great bulk of the operations performed in Jenner's time could still be regarded as recent even up till 1825, so that renewal of protection had not become acutely necessary. Coming now to the facts, the first quarter of the nineteenth century was characterized in this and other countries by a striking decrease of small-pox. In the London Bills of Mortality the small-pox deaths for the year 1800 were 2,409. From thence onward they diminished irregularly, there being only 421 in 1818, and this notwithstanding the great increase in population within the limits of the Bills. Exact data for comparison are scanty. The Commission point out that in Chester in 1775 about 93 per cent. of the inhabitants had had small-pox at one time or another, while in Cambridge in 1821 in almost the same amount of population, only about 34.4 per cent. of those who had been born during the twenty-five years had had small-pox, and of the 34 4 per cent. 12.7 had had it by inoculation. Norwich in 1820 also furnishes a contrast with places like Chester and Ware. In Sweden the mortality from 1774 to 1801 averaged 2,000 per million, and in 1800 was 5,000 per million, but then fell so rapidly that the yearly average was as high as 1,000 per million in one year only, namely 1809, while after 1816 it was often below 100 per million, rising again to nearly 500 per million in 1825. In Copenhagen small-pox suddenly declined after 1801, and its mortality entirely disappeared between 1810 and 1824. Similar changes are seen in other available records for Western Europe and the United States.

The Influence of Small-pox Inoculation.

The next point is whether the small-pox decline in the first quarter of the century can be attributed to causes other than vaccination. This leads to a short history of the practice of small-pox inoculation, and to the question whether its decline could account for the diminution of small-pox mortality. The general conclusion is that inoculation had a double influence—favourable because the fatality was

remarkably low, and unfavourable because the disease was infectious. Between the two it appeared to produce little effect on the total prevalence or mortality. There was certainly no such increase of small-pox coincident with increase of inoculation in the eighteenth century as to justify the decrease of inoculation being considered as the main cause of the marked decline of small-pox, and there is not even sufficient to show that it was a distinct subsidiary cause. Some antivaccinists hold that vaccination is in reality small-pox inoculation, and at the same time they hold that the decline in small-pox in the first quarter of the nineteenth century was due to the discontinuance of the practice of small-pox inoculation. The Commission point out that these theories are mutually destructive.

The Influence of Sanitation.

Could sanitation account for the small-pox decline in the first quarter of the nineteenth century? In the eighteenth century, places which were deemed the most salubrious seemed to have been visited by small-pox epidemics as severe as those which fell on unhealthy places. Regarding Chester, Haygarth writes "the healthiness of Chester," as shown by statistics, "must appear so extraordinary as to be almost incredible." Yet in that town 93 per cent. of the population in 1775 had had small-pox. The Commission conclude that "in general both the incidence of, and mortality from, small-pox seem to have been far less affected by sanitary conditions than might *a priori* have been expected." In Western Europe the decline of small-pox mortality was observed in countries where the sanitary conditions were widely different, and there is no ground to suppose that the period was marked by great improvements. That remark applies in many places long after the end of the first quarter of the century. The decline in small-pox "followed upon the introduction of the practice of vaccination. The records of Western Europe and the United States show that, in all places whence returns were obtained, the introduction of vaccination was followed by a decline of small-pox: the decline becoming specially apparent after the lapse of such time as may be supposed to be necessary for the due spread of the practice.

"Moreover, the spread of the practice and the decline of the disease do not stand as two phenomena simply following the same course, but without any tie joining the two. The experimental evidence offered at the time, namely, that the class of vaccinated persons did not take small-pox, by way either of exposure to natural contagion or of inoculation, as the unvaccinated did, connects the two and points to the spread of the practice as the cause of the decline."

Further, looking to the number of people already protected by small-pox, the amount of vaccination is sufficient to account for the amount of decline.

Vaccination Legislation.

The next part of the Report (Sections 90 to 126 inclusive) gives an account of vaccination legislation in the United Kingdom, and need not be summarized here.

Small-pox since 1837.

At Section 127 the Commission begin consideration of small-pox records under the Registration Acts, and tables are given showing the small-pox decline in England and Wales, and in London, from 1838 to 1894. Another table gives the vaccinations from 1872 to 1893. The corresponding figures for Scotland are given from 1854 to 1895 for small-pox, and from 1864 to 1893 for vaccinations. The small-pox mortality in Ireland is tabulated from 1864 to 1894. The Commission having pointed out how the statistics show that a more vaccinated population has exhibited a diminished mortality from small-pox, proceed to discuss whether vaccination has been the principal cause of the decline, the discussion having reference mainly to the allegation "that the decline has, in the main, been due to changes in the general conditions of life in the different parts of the United Kingdom, apart from the spread of the practice of vaccination; amongst other things, to improvement of sanitary conditions."

Influence of Density of Population.

They agree that an infectious disease like small-pox, other things being equal, is, owing to opportunities for contagion, more likely to spread in towns than in country districts, and in crowded town districts than in others less densely populated. Diminution of overcrowding of dwellings by diminishing such opportunities should so far check the prevalence of the disease and consequently lessen its mortality. In England and Wales, and in Scotland, a diminishing proportion of town population has been living in densely-built areas and in overcrowded dwellings. On the other hand, in these countries there has been a large increase in the total population. Still more important, a constantly growing proportion of the population lives in towns, and particularly in the larger towns. These changes would tend to spread small-pox. There is also "the enormous and continued extension of movement among the population and of communication with other countries, following the increasing facilities for such movement and communication." At the same time, however, the Commission find themselves unable to strike the balance between changes tending to diminish small-pox mortality and changes tending to increase it, but they hold that such changes do not afford any adequate explanation of the diminished mortality from small-pox.

Measles, Scarlet Fever, and Whooping-cough.

If improved sanitation were the cause of the diminution it should have exercised a similar influence over almost all other diseases, such as measles, scarlet fever, and whooping-cough, but these diseases have exhibited no such tendency. In explanation it has been urged that they affect children almost exclusively, while small-pox largely attacks adults; but in former days small-pox was more fatal to children than to any other class. The Commission give tables showing the mortality from measles, scarlet fever, and diphtheria in the three kingdoms, and they point out that the tables show no indication of decline comparable with that of small-pox. The same statement applies to whooping-cough.

Fevers.

As regards "fevers," the registered mortality has greatly diminished, but it is notorious that nomenclature and classification have greatly changed. The apparent diminution, however, is partly real; and drainage, ventilation, lighting, water supply, personal cleanliness, and some practical recognition of the power of contagion have had their share in causing this diminution. These sanitary changes, however, do not affect all zymotics alike. Typhus is related to overcrowding, and typhoid to excretal pollution. There is no like feature in the case of small-pox. "It resembles measles in this, that the spread of it is not connected with any particular sanitary fault, as distinguished from those general conditions which tend to the spread of infectious disease. There is no evidence in the history of small-pox, either before or during the nineteenth century, to connect outbreaks of that disease in a special way either with imperfect removal of excreta, or with lack of air and light, or with deficient food, or with lack of personal cleanliness. Moreover, the general tendency of sanitation to lower the prevalence and the fatality of the disease is largely neutralized both in the case of small-pox and measles by the greater facility of intercourse."

Isolation

The next question mentioned is the influence of isolation on small-pox prevention, but that is discussed more fully later on in the report, and at this stage all that the Commission point out is that "it is only in quite recent years that there has been any systematic practice of isolating small-pox patients, and that it has been confined even then to a very limited number of localities" (p. 46). The fact that the decline in small-pox deaths has been found almost exclusively among the young is also against the view that isolation is an important agency. "If a better system of isolation had been a main cause of the reduced mortality, we should have expected to see it operate in the cases of adults as well as of children."

AGE-INCIDENCE OF SMALL-POX.

This important question is now (Section 170, et seq.) discussed at more length by the Commission. To begin with, it is necessary to bear in mind that the effect of vaccination is not to be regarded as absolutely permanent. Its protection

against attack is held to diminish after the lapse of nine or ten years, though its power to modify the disease and render it less fatal remains in full force for a longer period, and never altogether ceases. Jenner's belief in the permanence of the protective effect of vaccination was, therefore, a mistake.

It has already been pointed out that in the last century small-pox was fatal chiefly to children, and in some local epidemics was confined entirely, or almost entirely, to them. The adults were very largely protected by previous small-pox. On the other hand, during the nineteenth century, few adults are protected by small-pox, and if vaccine is most potent during the first few years after its inoculation, the experience of the eighteenth century should be reversed, "children would be the best, adults the worst protected class." The following table shows the changes that have taken place in age-incidence between 1848 and 1894.

England and Wales: Deaths from Small-pox at certain Age-Periods to 1,000 Deaths from Small-pox at all Ages.

	Under 1.	1-5.	5-10.	10-15.	15-25.	25-45.	45 and upwards.
1848-54	251	426	130	33	75	67	18
1855-59	231	328	144	37	117	112	31
1860-64	237	313	108	42	123	133	44
1865-69	231	314	103	33	126	145	48
1870 74	143	169	140	58	200	224	66
1875-79	112	129	113	72	218	266	90
1880-84	113	122	98	68	216	286	97
1885-89	112	81	54	51	229	344	129
1890-94	166	117	50	26	131	338	172

Regarding this table the Commission speak as follows (Section 171):

The first point calling for notice is that in the period 1855-59, as compared with the earlier period, there was a considerable diminution in the share of small-pox mortality borne by those between 1 and 5 years of age. In the earlier period it was 426, in the latter 328. As regards those under 1 year of age the share fell from 251 to 231. It must, of course, be remembered that whatever the prevalence of vaccination amongst children, the age-period under 1 year will always contain a considerable unvaccinated class. We are naturally led to inquire whether there is anything in the history of vaccination to account for the remarkable change we have adverted to. In the year 1853 vaccination was made compulsory, and though no sufficient means were provided for rendering the law effectual, it cannot be doubted that it was calculated to increase vaccination in the subsequent years.

The next marked change is seen in the quinquennium 1870-74. The proportion of small-pox mortality borne by those under 1 year of age decreased from 231 to 143, and of those between 1 and 5 years of age from 314 to 169. We have already called attention to the fact that in 1867 power was given to the guardians to appoint vaccination officers, and that advantage was taken of this from time to time by different unions, though a large number remained without such officers until after 1871, when their appointment was made compulsory. There can be no doubt that the effect of this legislation was to cause an increasing extension of the practice of vaccination in 1868 and subsequent years, and very largely to increase the amount of vaccination in and subsequently to the year 1871. The effect of this would be at once felt in the earliest age-periods, and at a period correspondingly later in the succeeding age-periods. We have already pointed out the marked change in the incidence below 5 years of age in the quinquennium 1870-74, and it will be seen that in subsequent quinquennia there was a diminished incidence in the age-periods 5 to 10 and 10 to 15, and later still in the period 15 to 25. During the last quinquennium there has been some increase in the incidence of the disease in the first two life-periods. This has been coincident with some diminution in the practice of vaccination.

The next table shows the death-rates per million living at various ages in the period from 1848 to 1894.

	Under 5.	5-10.	10-15.	15-25.	25-45.	45 and upwards.
1848-54* ...	1,514.0	323 0	91.0	110.0	69 0	24.0
1855-64	788 8	209.5	68.7	118 9	87.8	36.2
1865-74	782.5	333.2	142.3	267.2	220.7	87.5
1875-84	127.8	62.9	46 4	82 4	76.6	33 9
1885-94	50.2	14.9	11.1	24.0	31.6	19.0

Deaths registered from "chicken-pox" are included in 1848-54.

The comments of the Commission on this table are of much interest, but are too lengthy for quotation here. The general lesson which it teaches is fairly obvious.

Age-incidence in Scotland.

A table of age-incidence is given for Scotland, and attention is called to the fact that the proportion of deaths borne by children under 6 months was almost exactly the same in the period 1855 to 1863 (prior to the Scottish Vaccination Act); as in the period from 1864 to 1887 (subsequent to the Act). Vaccination being compulsory in Scotland at the age of 6 months, this first half year of life includes practically an unvaccinated class. On the other hand the proportion per 1,000 of deaths borne by children between 6 months and one year fell from 153 to 47 between the two periods, and in children between 1 and 5 years it fell from 413 to 137. It was vaccination, therefore, that made the difference.

Age-incidence in Modern Epidemics in Sheffield, Warrington, Gloucester, etc.

A very valuable part of the Commission's Report is that which records the results of investigation of six local epidemics of small-pox belonging to quite recent years. The first was the Sheffield epidemic of 1887-88, reported on by Dr. Barry. The other five inquiries were conducted by medical men appointed by the Commission—Dr. Coupland on epidemics in Dewsbury and Leicester in 1891-92, and 1892-93 respectively; Dr. Luff on outbreaks in London in 1892-3; Dr. Savill on an epidemic in Warrington in 1892-3; and Dr. Coupland on an epidemic in Gloucester in 1895-6. The age-incidence of fatal small-pox in these epidemics is of great interest. In Sheffield the disease had been epidemic in 1857-58 and 1863-64. Of every 100 small-pox deaths in these two outbreaks, 85 per cent. in the former, and 86 per cent. in the latter, were among children under 10 years, and only the remaining 14 or 15 per cent. were in persons over 10 years. In an epidemic in 1868-9 the children's share was 84 per cent., but in the 1871-2 epidemic the children's share had fallen to 64, and in the 1887-8 epidemic it fell further to 27 per cent., no less than 73 per cent. being borne by persons aged 10 years and upwards.

The Commission give a table showing the percentage of small-pox borne by children in the recent epidemics in the six towns already referred to. It is convenient to amplify their table so as to show the dates, and the vaccinnal condition of the six towns, as follows:

Percentage of Total Small-pox Deaths borne by Children under 10 Years of Age, in Recent Outbreaks in various Towns.

Towns, and Dates of Epidemic.	Vaccination Default.	Percentage of Total Small-pox Deaths borne by Children under 10 years of age.
Warrington, 1892-3 ...	Very slight	22.5
Sheffield, 1887-8... ...	Very slight	25.6
London, 1892-3	In 1883-91, 10 per cent.	36'8
Dewsbury, 1891 2 ...	In 1882-92, 32 3 per cent.	51.8
Gloucester, 1895-6 ..	In 1885-94, 10 6 to 85.1 per cent.	64.5
Leicester, 1892-3 ...	In 1883-92, 43 8 to 80.1 per cent.	71.4*

*Or 66.6 (See Section 182 Final Report).

The Commission write:

We cannot but lay stress upon the facts thus revealed by the investigation of recent epidemics in these six towns. These facts are not open to the same chance of error as is involved in a comparison of the mortality among persons said to be vaccinated or unvaccinated. The age at which deaths occur may be said to be practically a matter of certainty, whilst the proportion of deaths below a given age to deaths above that age is free from liability to error. And even if the proportion of vaccinated to unvaccinated children under 10 be not capable of precisely accurate ascertainment, there can be no doubt that the proportion was very great in Warrington and Sheffield and very small in Gloucester and Leicester, whilst in London and Dewsbury it lay somewhere between the two: and the proportion of the unvaccinated in Dewsbury may with confidence be asserted to have been greater than in London.

Age-incidence in Healthy Districts.

The Commission, indeed, have no difficulty in finding that the phenomena of small-pox age-incidence are accountable by vaccination. They ask, "Is there any other satisfactory explanation?" and in that connexion they revert once more to the question of the influence of sanitation. In the Registrar-General's "Healthy Districts" the percentage of small-pox deaths under 5 years of age is very much less than in Liverpool; but, apart from any other elements of sanitation, such as water and drainage, and so forth, the density of population in the Healthy Districts is much less, and there is less opportunity for conveying infection from individual to individual, so that fewer are infected, and at later ages. About 95 per cent. of the whooping-cough deaths are under 5 years of age alike in Liverpool and in the Healthy Districts, but the explanation is that whooping-cough rarely kills persons over 5. In measles the percentage borne by children under 5 is 94 5 in Liverpool, and 76 in the Healthy Districts; but here again, though measles may attack susceptible persons of any age, it is rarely fatal except in the young, and in great towns there is more exposure to infection. Throughout this argument, however, the Commission do not give sufficient attention to the basis of the Registrar-General's classification. A Healthy District, in his view, is simply a district whose crude death-rate is under 15 per 1,000 per annum. He makes no inquiry whatever as to sanitation in the shape of drainage, water supply, refuse removal, good house accommodation, and so forth. Many so-called Healthy Districts have damp houses with little drainage and poor water supply, and no organized system of refuse removal. The one great fact in their favour is that the population is widely scattered in single houses or hamlets or villages, and that there is comparatively little opportunity for spread of infection. To argue, therefore, from the experience of such districts that drainage and water supply, and so forth, are useful in preventing small-pox is obviously folly. These places have no superiority, but, as a rule, great inferiority, in drainage and water supply, etc. Their small-pox age-incidence depends wholly on the fact that the inhabitants are so far apart that there is much diminished opportunity for receiving infection. A fallacy to which the Commission do call attention is that in Liverpool in a million children born alive, a much smaller number reach the ages beyond 5 years than in healthy districts, so that small-pox, which attacks and is fatal at all ages, will find a greater percentage of victims above 5 years in Healthy Districts than in Liverpool.

Influenza and Age-incidence.

As regards any comparison with "fevers," the nomenclature and classification have already been referred to. In influenza a comparison between the short epidemic periods of 1847-8 and 1890-1 is of little value, and the case is much confused by the registration of influenza deaths as due to pneumonia, bronchitis, heart disease, etc. In influenza the age-period over 65, and that under 15, have a smaller share of the registered deaths in the later than in the earlier epidemic, but it is impossible to say to what extent pneumonia, bronchitis, etc., were registered in the earlier period.

The general conclusion regarding age-incidence is (Section 201) as follows:

Apart from the difference in the extent of vaccination, no cause has been suggested at all adequate to account for the variations in the age incidence of fatal small-pox upon which we have been dwelling. It is not only that it is seen at different epochs equally prominent in England and Wales, Scotland, and Ireland, but a striking contrast in the proportion of mortality below and above 10 years of age is witnessed, also, at the same epoch in different towns where small-pox happened to become epidemic—places which differ, so far as is known, only in this, that the extent of vaccination amongst the child population was different. If improved sanitation were the cause of the diminished mortality amongst children, in proportion to that borne by those of older years, it is quite impossible to understand how its effect should have varied so greatly in these different towns, and why in Gloucester and Leicester the mortality from the disease should have been so largely amongst children, approaching in that respect the experience of the epoch preceding vaccination.

FATALITY OF SMALL-POX AMONG VACCINATED AND UNVACCINATED.

The next subject treated of is the fatality of small-pox amongst the vaccinated and the unvaccinated. It is discussed with relation to the six epidemics already mentioned and the hospital statistics of Drs. Marson, Gayton, and Sweeting. Each group of statistics points to the same conclusion—that the fatality-rate is very much less in the vaccinated than in the unvaccinated.

Fatality in Sheffield.

In the Sheffield epidemic, in the enumerated population, among 4,151 persons of all ages attacked by small-pox 200 or 4.8 per cent. died. Of 552 unvaccinated, 274 or 49.6 died. Of 353 vaccinated children under 10 years old, 6 or 1.7 per cent. died. Of 228 unvaccinated children 100 or 43.9 per cent. died. Relatively to the numbers attacked, for every vaccinated child that died, no less than 25.8 unvaccinated died. Of 3,174 vaccinated persons over 10 years of age attacked by small-pox 194 or 5.1 per cent. died. Of 322 unvaccinated 174 or 54 2 per cent. died, so that the fatality-rate over 10 was 10.6 times as great in the unvaccinated as in the vaccinated. The same general features are observable in the different districts of Sheffield.

In London.

In London in 1892-93, 110 vaccinated children under 10 were attacked and none died, while 228 unvaccinated children were attacked of whom 61 died. Over 10 years of age 1,643 vaccinated were attacked and 39 died or 2.3 per cent., whilst 181 unvaccinated were attacked and 38 died or 20.9 per cent. In these figures all doubtful cases are discarded, but even if all of them be added to the vaccinated, the teaching is the same, the fatality-rate of vaccinated children under 10 being then 4.6 per cent. as compared with 26 7 per cent. among the unvaccinated, while over 10 years the corresponding percentages are 4.2 and 20.9.

In Dewsbury.

In Dewsbury, 44 vaccinated children under 10 were attacked and 1 died, or 2.2 per cent., while 174 unvaccinated children were attacked and 56 died, or 32.1 per cent. Over 10 years old, 577 vaccinated cases had 15 deaths, or 2.6 per cent., and 192 unvaccinated cases had 36 deaths, or 18 7 per cent. The Commission include in the unvaccinated "those under vaccination," because their inclusion tells on the whole in favour of the unvaccinated. On the other hand, doubtful cases have been included in the vaccinated class.

In Warrington.

In Warrington, 33 vaccinated children attacked under 10 had 2 deaths, or 6 per cent., and 32 unvaccinated had 12 deaths, or 37.5 per cent. Of 560 vaccinated over 10, 36 died, or 6.4 per cent., and of 36 unvaccinated persons of a similar age, 12 died, or 33.3 per cent.

In Leicester.

In Leicester, 2 vaccinated children under 10 were attacked, neither of whom died, while 107 unvaccinated were attacked and 15 died. Over 10 years, 197 vaccinated were attacked and 2 died, or 1 per cent., while 51 unvaccinated were attacked and 4 died, or 7.8 per cent.

In Gloucester.

In Gloucester, 26 vaccinated children under 10 were attacked and 1, or 3.8 per cent., died, while 680 unvaccinated were attacked and 279, or 41 per cent., died. Over 10 years, 1,185 vaccinated attacks had 119 deaths, or 10 per cent., and 88 unvaccinated attacks had 35 deaths, or 39.7 per cent.

Variations in Fatality rates.

Independently of vaccination, the fatality-rate in the different epidemics varied greatly. Among persons over 20 years old there was probably little difference in these towns as regards their vaccination, but in Gloucester the fatality-rate among those over 20 years of age was 14 per cent., in Sheffield 10.9, in Warrington 10.3, in Dewsbury 8, in London 7, and in Leicester 2.2.

Conclusions as to Fatality-rates in the Six Towns.

Adding up the figures for the six towns the unvaccinated attacked were 2,321, of whom 822 died, or 35.4 per cent. Among the vaccinated population the attacks were 8,744 and the deaths 461, or 5 2 per cent. Confining the comparison to children under 10 the result is still more remarkable. The total attacks in the six towns were 2,038 with 539 deaths, or 26.4 per cent. Of these 1,449 were unvaccinated with 523 deaths, or 36 per cent., and 589 were vaccinated with 16 deaths, or 2.7 per cent. Regarding these figures the Com-

missioners ask:—"Upon the hypothesis, then, that vaccination has no relation to small-pox, and no tendency to mitigate the effect of the disease, we have before us an arbitrary selection which might just as well have been made by drawing lots of 20.9 per cent. of the total number of persons attacked; why should those thus selected display so remarkably different a proportion of fatal cases, a death-rate to attacks of 35.4 per cent. in the one class and 5.2 per cent. in the other?" If it be said that children under three months are almost all unvaccinated and that these help to account for the greater fatality in the unvaccinated, the reply is easily made by excluding all under 1 year of age. The figures then come out as follows:—Among the vaccinated between 1 and 10 years 570 attacks and 16 deaths, or a fatality of 2.8 per cent. Among the unvaccinated 1,235 attacks and 375 deaths, or a fatality of 30.3 per cent.

"The contrast is the more striking when it is remembered that all the doubtful cases are included in the vaccinated class, though many of them had, in all probability, never been successfully vaccinated. The doubtful cases in London alone account for 6 out of the 16 deaths, and raised the fatality from 1.8 to 2.8 per cent.

"Is the different fatality manifested in the two classes into which the children between the ages of 1 and 10 years who were attacked by small-pox are thus divided, according as they were or were not vaccinated, a mere freak of chance? It is scarcely possible to believe that it can be so. When it is found that the same contrast is exhibited on comparing the fatality among the classes of vaccinated and unvaccinated in each of the six towns with which we have been dealing, and even in different districts of Sheffield and Dewsbury, where a similar discrimination between the vaccinated and unvaccinated was made, and when it is borne in mind that both classes lived in the same towns, were of similar ages, and suffered in the same epidemics, it is impossible to believe that there was nothing to distinguish the two classes from one another."

Hospital Fatality-rates.

Continuing the argument regarding the difference of fatality as between the vaccinated and the unvaccinated, Marson's observations during 32 years at the London Small-pox Hospital are next referred to, but these fall to be discussed in more detail later on. At Homerton Hospital Dr. Gayton treated 1,043 cases between 1873 and 1884, including among the vaccinated all who were said to be so, even if they had no marks. They had 869 deaths in 8,234 cases, or 10.5 per cent., while the unvaccinated had 938 deaths in 2,169 cases, or 43.4 per cent. Paying regard to the ages, there were under 10 years 1,306 vaccinated, with 137 deaths, or 10.4 per cent., and 1,187 unvaccinated, with 563 deaths, or 47.3 per cent.

At Fulham Hospital between 1880 and 1885 Mr. Sweeting had 2,584 cases. The deaths among the vaccinated, including those said to be vaccinated, but without marks, were 263 in 2,226 cases, or 11.4 per cent., and among the unvaccinated 165 in 358 cases, or 46 per cent. Under 10 years of age the vaccinated were 202, with 16 deaths, or 7.9 per cent., and the unvaccinated 168, with 78 deaths, or 46 per cent.

The argument that the classification of cases was open to error because some individuals might, on admission, have the eruption of confluent small-pox concealing vaccination marks need hardly be regarded, as both Dr. Gayton and Mr. Sweeting state that this happened very rarely. The fact that Dr. Jurin in the eighteenth century collected some figures relating to local epidemics between 1720 and 1730 with a much less average fatality than that of the unvaccinated in the present day throws no doubt on the correctness of the classification made in modern epidemics. The fatality of small-pox varies greatly in different outbreaks, and it varied greatly in the eighteenth century.

Antivaccinist Explanations.

Another allegation made in explanation of the above contrasts between the vaccinated and the unvaccinated is that "the unvaccinated are mostly to be found in the poorer and more neglected classes of the population, who would on that account be constitutionally weaker and less able to resist an attack of small-pox and to escape a fatal result."

But in the epidemics in Warrington, Dewsbury, and Sheffield it is shown that this explanation cannot be correct. At Warrington, Dr. Savill expressly stated that the vaccinated and the unvaccinated were of the same class, and lived in the same houses and in the same manner. The admissions to Homerton and Fulham Hospitals, whether vaccinated or unvaccinated, were mostly of the pauper class or that immediately above it. The disparity of the death-rates in the vaccinated and in the unvaccinated was greater near the date of vaccination than at a later period, and this is observable alike in the six towns and in the hospitals. The Commission might also have pointed out that in places like Leicester and Gloucester, where antivaccination is the fashion, the unvaccinated could not specially belong to the poorest classes.

It has also been alleged that the unvaccinated include cases postponed for medical reasons, but the number of such postponements is small, and they do not necessarily show a delicate constitution, but are often due to ailments affecting the strong no less than the weak. Postponed cases also are vaccinated at a later period, and the postponement is usually for a short time only.

THE ATTACK-RATE OF SMALL-POX AMONG THE VACCINATED AND THE UNVACCINATED.

Having dealt with fatality-rates, the next question is attack-rates. With regard to the Sheffield epidemic, in order to

Attack rates in Sheffield.

remove an objection raised the Commission added 28 per cent. to the unvaccinated population, and deducted this from the vaccinated. Even then the contrast was very striking:

Of 266,797 vaccinated persons of all ages, 4,151, or 1.55 per cent., were attacked by small-pox.

Of 7,315 unvaccinated persons of all ages, 552, or 7.5 per cent., were attacked by small-pox.

Of 67,603 vaccinated children under 10 years of age, 353, or 0.5 per cent., were attacked.

Of 2,892 unvaccinated children under 10 years of age, 228, or 7.8 per cent., were attacked.

Of 193,495 vaccinated persons aged 10 years and upwards, 3,774, or 1.9 per cent., were attacked.

Of 4,389 unvaccinated persons aged 10 years and upwards, 322, or 7.3 per cent., were attacked.

It is also to be noted that in each of the nine districts of Sheffield the same feature appeared of a much higher rate of attack among the unvaccinated than among the vaccinated.

Attack-rates in Invaded Houses.

The above figures refer to the entire enumerated population of Sheffield, but a different and very forcible comparison is to be made in the six epidemics. This is based on the experience of the population living in houses actually invaded by small-pox. It is impossible to quote all the figures here,

In Warrington.

but those with regard to Warrington may be noted, seeing that "Dr. Savill states that, bearing in mind the social class affected with small-pox, it may be taken as nearly certain that all the inmates of an infected house were exposed in some degree to infection either before or after recognition of the disease, either from the patient or from the same source as the patient."

In 437 infected houses for which precise information was available in Warrington there were 2,535 inhabitants of whom 41 were said to have had small-pox in previous years. This leaves 2,494. Of these, 2,387 had been vaccinated at some time or other in their lives before the houses became infected, including 100 persons about whose vaccination Dr. Savill was doubtful. The total attacks amounted to 553, or 23 per cent. In the same houses there were 107 unvaccinated persons, and among them 60, or 56 per cent., were attacked. These, as has already been noted, include all ages. Taking now children under 10, the total number was 688. Of these, 633 were vaccinated and 55 unvaccinated. Of the 633 vaccinated 28 were attacked, or 4.4 per cent. Of the 55 unvaccinated children 30 were attacked, or 54.5 per cent. Over 30 years the difference is much less striking, and this of course accords with the universally-held view that the power of vaccination diminishes with time. But it by no means disappears, for among 1,754 vaccinated persons over 10 years of age 525 were attacked, or 29.9 per cent., while among 52 unvaccinated persons over 10 years 30 were attacked, or 57.6 per cent. With reference to the contrast Dr. Savill says: "I could ascertain no reason for this remarkable difference in the attack-rate in the two classes, unless the fact of vaccination protected the vaccinated persons from being attacked by small-pox. Being members of the same families they lived in the same houses (which, be it noted, were of a remarkably uniform type), ate the same food, often did the same work, and were exposed to the same hereditary and external influences."

One highly infected area contained a population of 3,330 who had not previously had small-pox. All but 29 of these had been vaccinated at some time or other. Among the vaccinated there were 84 attacks, or 2.5 per cent. Among the 29 unvaccinated persons there were 6 attacks, or 20.6 per cent.

In Leicester.

In the Leicester epidemic, of 1,229 persons living in houses invaded by small-pox, 841 were vaccinated, of whom 170 were attacked, or 20.2 per cent., whereas 388 were unvaccinated, of whom 150 were attacked, or 38.6 per cent. Confining the comparison to persons under 10 years old, the vaccinated were 78, of whom 2 were attacked, or 2.5 per cent., while the unvaccinated were 283, of whom 100 were attacked, or 35 3 per cent.

In Gloucester.

In Gloucester 899 invaded houses contained 4,861 inmates. Under 10 years old there were 272 vaccinated children, of whom 24, or 1.8 per cent. were attacked. The unvaccinated were 1,331, of whom 667, or 46.3 per cent. were attacked.

In Children and Adults.

The following table gives the attack-rates in invaded houses of the vaccinated and unvaccinated among children under 10 years and persons over 10.

	Attack-rate under 10.		Attack-rate over 10.	
	Vaccinated.	Unvaccinated.	Vaccinated.	Unvaccinated.
Sheffield ...	7.9	67.6	28.3	53.6
Warrington..	4.4	54.5	29.9	57.6
Dewsbury ...	10.2	50.8	27.7	53.4
Leicester ...	2.5	35.3	22.2	47.6
Gloucester ...	8.8	46.3	32.2	50.0

The London Hospitals.

Turning to the London hospitals, the percentage of unvaccinated persons admitted to Homerton Hospital was 20.8, the numbers being 2,169 out of 10,403, while among children under 10 years old the unvaccinated admissions were 1,187 out of 2,493, or 47.6 per cent. At Fulham Hospital the unvaccinated were 13.8, and under 10 years 45.4. Obviously these are quite out of proportion to the numbers of the unvaccinated in the population from which they were drawn. The children not finally accounted for in the London vaccination returns from

At Highgate Hospital.

1872 to 1884 averaged only 7.4 per cent. At Highgate Small-pox Hospital the proportion of vaccinated patients admitted was often as high as 94 and 95 per cent., but the Commission point out that the total numbers were much smaller than at Homerton or Fulham, and that the inmates of the Highgate Hospital belonged in part to a more prosperous class among whom omission to vaccinate is rare. Many of them come from outside of London. The Commission appear not to have been aware of the additional and very important fact that Highgate Hospital had for many years admitted no children under 7 years old. The admissions, therefore, were from a class among whom the protection of vaccination had considerably diminished. It is part of the doctrine of vaccination that protection against attack diminishes more quickly than protection against death by small-pox. These Highgate figures relate to attack only, and the importance of this consideration regarding the age of admitted patients is, therefore, all the greater.

Severity of Type of Small pox.

The Commission next discuss the severity of type of small-pox among vaccinated and unvaccinated in five of the six epidemics. As we have already, however, given the data regarding fatality, it seems unnecessary to dilate on severity of the type, especially as deaths and recoveries from small-pox are more definite facts to deal with than classifications of the type of the disease.

THE VALUE OF VACCINATION MARKS OF DIFFERENT NUMBER AND AREA.

Three Standards of Efficiency.

Efficient as distinguished from inefficient vaccination is the question here dealt with by the Commission. The matter may be considered from three standpoints, the number of marks, the total area, and their foveation. These, again, have to be thought of in relation to the length of time that has elapsed since vaccination. The standards adopted by different observers, whose results are given by the Commission, are not identical, so that it is difficult here to attain to any large totals. In Sheffield, however, Dr. Barry gives the facts for

In Sheffield.

825 vaccinated cases. Ninety-five of these had no visible primary cicatrices, and 13 of them died, or 13.7 per cent.; with two primary cicatrices there were 259 cases with 4 deaths, or 9.3 per cent.; with three primary cicatrices there were 372 cases, with 21 deaths, or 5.7 per cent.; with four or more primary cicatrices there were 99 cases, with 2 deaths, or 2 per cent.

In Dewsbury.

In the Dewsbury epidemic the total area of the scars was noted in 290 cases; 246 of these had an area of at least half a square inch, and among them there were 3 deaths, or 1.2 per cent.; 27 of them had an area of between a-third and half an inch, and among them there was 1 death, or 3.7 per cent.; 17 had an area of less than a-third of a square inch; 1 of the 17 died, or 5.8 per cent.

In London.

In London Dr. Luff investigated and reported on the foveation of scars in 1,018 small-pox attacks. In persons with foveated scars there were 971 discrete cases, and 47 severe or confluent cases. On the other hand, in 562 persons whose scars were not foveated, the number of discrete cases was 503, and of severe and confluent 59. "An examination of the total numbers shows that in the foveated class 95.3 cases were discrete, while 4.6 were severe or confluent, and that in the unfoveated class 89.5 were discrete, and 10.4 severe or confluent." The death-rate among the 1,018 foveated cases was 1.2 per cent. Among the 562 unfoveated it was 3.2 per cent.

In Warrington.

In Warrington the death-rate was 2.9 in 350 well vaccinated cases, and in 208 indifferently vaccinated cases it was 8.2 per cent.

The Hospitals: Homerton.

Turning now to hospital experience, in Homerton:

Of 529 persons with 1 good mark, 22 died, or 4.1 per cent.
Of 649 ,, ,, 2 ,, marks, 22 ,, 3.3 ,,
Of 518 ,, ,, 3 ,, ,, 12 ,, 2.3 ,,
Of 389 ,, ,, 4 or more good marks, 6 died, or 1.5 per cent.

Fulham.

The following table gives Mr. Sweeting's experience at Fulham Hospital, the cases being classified according to age:

	One Mark.			Two Marks.			Three Marks.			Four Marks and Over Four Marks.		
	Cases	Deaths.	Death-rate.	Cases.	Deaths.	Death-rate.	Cases.	Deaths.	Death-rate.	Cases.	Deaths.	Death-rate.
0-10	21	1	4.76	29	1	3.45	37	0	0.00	53	0	0.00
Over 10 years of age	384	41	10.68	509	46	9.04	459	37	8.06	396	19	4.80
At all ages ...	405	42	10.37	538	47	8.73	496	37	7.45	449	19	4.23

Marson's Experience.

These results constitute no new experience. The next table is based on Mr. Marson's observations at the London Small-pox Hospital, and relates to 3,094 cases of post-vaccinal small-pox from 1836 to 1851, and 10,661 cases from 1852 to 1867:

Cases of Small-pox Classified According to the Vaccination Marks borne by Each Patient Respectively.	Percentage of Deaths in each Class Respectively: Uncorrected.*		Percentage of Deaths in each Class Respectively: Corrected.*	
	1836-51	1852-67	1836-51	1852-67
1. Stated to have been vaccinated, but having no cicatrix...	25 5	40.3	21.7	39.4
2. Having one vaccine cicatrix	9.2	14.8	7.6	13.8
3. Having two vaccine cicatrices	6.0	8 7	4 3	7.7
4. Having three vaccine cicatrices ...	3 6	3 7	1.8	3.0
5. Having four or more vaccine cicatrices	1 1	1.9	0 7	0.9
Unvaccinated	37.5	35.7	35.5	34.9

* The terms *uncorrected* and *corrected* are used to signify the inclusion or exclusion of those fatal cases of small-pox in which the patient suffered from some other disease superadded to the small-pox.

The total number of cases whose statistics were before the Commission classified according to marks exceeded 20,000. Apart from Marson's cases the number was 6,839, and the following is a summation of the results:

1 Mark,	1,337	cases, with	85	deaths, or	6.2	per cent.
2 Marks,	1,971	,, ,,	115	,, ,,	5.8	,,
3 ,,	1,997	,, ,,	75	,, ,,	3.7	,,
4 ,,	1,514	,, ,,	34	,, ,,	2.2	,,

The Commission's Conclusion.

The conclusion of the Commission is:

Upon the whole, then, the evidence appears to point to the conclusion that the greater the number of marks the greater is the protection in relation to small-pox enjoyed by the vaccinated person. This further indication also seems to be afforded—that whilst the distinction in this respect between those with one and those with two marks is not very great, there is a very marked contrast between those with four, or even with three, marks as compared with those with either one or two.

Revaccination.

The amount of exact statistical material relative to revaccination is much less than in the case of primary vaccination.

Revaccination in Sheffield.

In the Sheffield epidemic of 1887 88, Dr. Barry appealed through the public press and to the medical profession for information of small-pox attacks among revaccinated persons. From all sources he heard of 352 cases and personally inquired into the whole of them. Twenty-three had removed and could not be traced; of the other 329, some had never had small-pox, some had never been vaccinated, some had been vaccinated or revaccinated during the incubation of small-pox, and some had been revaccinated unsuccessfully. Twenty-six persons had been revaccinated successfully prior to the incidence of small-pox. These were inspected, and in addition one person, who had been successfully revaccinated, was fatally attacked by small-pox in 1887. The number of persons found to have been attacked by small-pox after successful revaccination was thus 27 in all.

Of the 27 cases of small-pox 1 ended fatally. His revaccination was 18 years old. In 19 the disease was "extremely mild," in 2 there was a copious eruption but no pitting, in 3 the attack was severe, and in 2 of these there was slight pitting, while in the third there was bad pitting. In the third it was doubtful whether the disease had been small-pox.

The Commission point out that a person cannot be properly called revaccinated unless vaccinia has really been induced. It is well known that one attempt at revaccination may fail and a repetition of the process in the same person may succeed a few days afterwards.

"If a revaccination is unsuccessful, it ought not from that fact to be taken for granted that immunity is certain, but the operation should be repeated once or even twice, as in the case of failure of primary vaccination in infants."

In Sheffield the total number of revaccinated persons was 64,431. As already noted, 27 of these were attacked by small-pox, the attack-rate being 0.04 per cent.

Second Attacks of Small-pox.

It is noted that small-pox itself is occasionally followed by a second attack of the same disease. In Sheffield 18,292 persons were reported as having had small-pox prior to 1887. Of these, 23 were attacked during the epidemic, so that their attack-rate was 0 13 per cent.; 5 of the 23 died. These rates are higher than those of the revaccinated. In Dewsbury, Warrington, and Leicester there were 12 second attacks of small-pox without a single death.

Revaccination in Leicester.

In Leicester, during the epidemic, one group of 133 houses had 842 inmates, of whom 141 were attacked. These houses contained 84 revaccinated persons, of whom 1 was attacked. In another group of 60 houses with 392 inmates there were 179 attacks, and among 31 revaccinated persons there were 5 attacks. In the first group the attack-rate in the vaccinated was 14 6 per cent., in the revaccinated 1.1 per cent. In the second group the attack-rate among the revaccinated was 16 1 per cent., amongst the vaccinated 30.3 per cent., and amongst the unvaccinated 59.6 per cent. In the Report figures are given for other outbreaks.

In the Troops in Sheffield.

The Sheffield epidemic throws an interesting sidelight on revaccination in the army. The average number of troops stationed in the town during the epidemic was 830. All these ought to have been revaccinated.

Twelve men, or 1.4 per cent. of the total strength, contracted small-pox, and of these one died. Not one of the soldiers who contracted small-pox had been successfully revaccinated. During the period of the epidemic the men mingled freely with their friends in the town, and although the neighbourhood of the barracks was one of the first localities invaded by the disease, no successfully revaccinated soldier quartered in Sheffield suffered from small-pox.

The Commission make no comment on the cases of these twelve men, but they indicate that the thoroughness of the revaccination of the army is open to question. No doubt the attempt was made but it would be interesting to know how often it was repeated before being given up.

In the Sheffield Post Office.

In the Sheffield Post Office there were 290 men and boys. The regulations required revaccination before engagement.

Dr. Barry truly points out that the duties of letter carriers, telegraph boys, etc., continually bring them into personal contact with infected persons and things, yet no member of the permanent staff of the Post Office contracted small-pox.

There seems a suggestion here that revaccination in the Postal Service was better carried out than in the army.

Small-pox Hospital Nurses.

The revaccination of the nurses of small-pox hospitals is next dealt with by the Committee.

In Sheffield.

There were four hospitals in Sheffield with 315 beds besides a convalescent hospital with 60 beds. The total small-pox cases in the year ending March 31st, 1888, were 1,798. The total number of attendants in personal contact with the sick was 140. Besides, there were 21 persons in constant communication with the attendants. Of the 161, 18 had had small-pox previously and none of the 18 contracted the disease again. One person had a mild attack of small-pox fourteen days after entering the hospital and only a few days after successful revaccination. Sixty-two had been vaccinated in infancy only, of whom 6 took the disease and 1 died. Eighty were successfully revaccinated and not one contracted small-pox.

At Warrington.

At Warrington two members of the hospital staff were attacked by small-pox. They were the only two who had not been revaccinated at the beginning of the outbreak, one of them having been vaccinated a few days before the appearance of the small-pox eruption.

The Leicester Small-pox Nurses.

At Leicester the hospital staff consisted of 40 persons, of whom 20 had been vaccinated or revaccinated shortly before beginning duty, 14 had had small-pox or been revaccinated

at some previous time, and 6 refused revaccination. Among the 20 and 14 there was one mild case of small-pox in a person whose revaccination was 10 years old. Of the 6 who refused revaccination 5 were attacked by small pox, and one, said to be of intemperate habits, died.

At Homerton.

At Homerton Hospital in the years 1871-7, 366 persons were employed. All were revaccinated on beginning duty with one exception—a nurse who escaped notice. A fortnight afterwards she lay down with a severe attack of small-pox, ending in recovery. The experience of later years at Homerton has been similar.

At the Hospital Ships.

On the hospital ships on the Thames in the 12 years 1884-95 the staff varied from below 50 to over 300, and the total number of attacks among them during the period was 12. In one of these the disease appeared within 3 days of entering, in another 9 days, in 4 others 10 days, and in 4 others 12 to 15 days after joining the staff. None of the 12 had been successfully revaccinated prior to the incubation of small-pox, though the operation had been attempted shortly after joining.

At Fulham Hospital.

At Fulham Hospital whilst it was used for small-pox the staff was 362, of whom about half were habitually employed in the wards. Of the 362, 48 had already had small-pox. Of the other 314, 7 were attacked; 2 of these had not been revaccinated owing to an oversight; two were unsuccessfully revaccinated, one of them being a case of second small-pox; another was not revaccinated early enough, and in the other 2 there is no record of any result. The ambulance staff numbered 42, of whom 1 escaped revaccination, his arrival not having been reported. He contracted small-pox thirteen days after beginning duty. He was the only one who took small-pox.

At Highgate Hospital.

At the Highgate Small-pox Hospital in sixty years there has been only 1 attack among the members of the staff, a gardener who had not been revaccinated.

At Dublin.

It will be seen that the cases above reported are just such exceptions as are useful in proving a rule. Some evidence was placed before the Commission that in the Dublin Hospital in 1871-2 a number of nurses who had not been revaccinated escaped small-pox. The evidence was rather hazy, but there is no reason to dispute the fact that primary vaccination sometimes gives lengthened protection, even against attack.

The Bicêtre Hospital.

A more or less similar statement regarding the Bicêtre Hospital in Paris is subject to similar comment.

Antivaccinist Explanations.

With reference to the suggestion that the immunity of small-pox hospital nurses is due to long and gradual exposure to the poison, there are three observations. In the first place, the exposure is not gradual; in the second place, it does not protect those who have not been revaccinated; and in the third place there is no parallel to such protection against other infectious or contagious diseases.

Typhus Fever Nurses.

This is shown by experience of typhus when that disease was common enough to furnish proof. In 1862-71 in the London Fever Hospital the attendants in the course of a year averaged about 100, and the average number of attacks of typhus among them was 19.2, even though some of the 100 were not employed in the typhus wards. In 1862 the resident medical officer and a *locum tenens* caught typhus. In 1863 the resident medical officer and three successive assistants also caught it; in 1864 the assistant resident medical officer, and in 1865 another medical officer contracted the disease; and in 1866 the resident medical officer took it and died.

Nurses for Other Infectious Diseases.

Seeing that most people have had scarlet fever and measles in childhood, there is less opportunity for members of a hospital staff to be attacked by these diseases, and the infectivity of typhoid can hardly be compared with that of small-pox, yet the following table furnishes a very striking contrast with small-pox.

Year.	Metropolitan Asylums Board's Fever Hospitals.*			Metropolitan Asylums Board's Small-pox Hospital Ships.		
	Number of Attendants Employed either Temporarily or otherwise in the Course of the Year.	Of whom, there Contracted Scarlet Fever, Diphtheria,† or Typhoid during the Year.		Number of Attendants Employed either Temporarily or otherwise in the Course of the Year.	Of whom there Contracted Small-pox during the Year.	
		Number.	Proportion.		Number.	Proportion.
1884	Figures not available	—	—	283	4	1.4 per cent.
1885				240	0	0.0 ,,
1886				110	0	0.0 ,,
1887	1,103	37†	3.4† per cent.	55	0	0.0 ,,
1888	Figures not available	35	—	46	0	0.0 ,,
1889		42	—	53	0	0.0 ,,
1890	1,312	53	4.0 per cent.	64	0	0.0 ,,
1891	1,160	68	5.9 ,,	64	0	0.0 ,,
1892	1,652	121	7.3 ,,	138	2	1.4 ,,
1893	2,175	121	5.6 ,,	320	6	1.9 ,,
1894	2,182	111	5.1 ,,	289	0	0.0 ,,
1895	2,514	116	4.6 ,,	274	0	0.0 ,,

* Excluding the Gore Farm Hospital, opened in 1890. In the years 1893, 1894, and 1895 both scarlet fever and small-pox convalescent patients were admitted into that hospital, and the only available figures as to the staff do not enable us to distinguish between those employed in or about the fever, and those in or about the small-pox, wards.

† Cases of diphtheria, as such, were not admitted into the Metropolitan Asylums Board's hospitals prior to October, 1888; though a few cases of that disease, sent in as fever cases, had been admitted in the earlier part of that year and in the previous year. Three attendants who contracted diphtheria in 1887 have not, therefore, been included in the number (37) and proportion (3.4 per cent.) given in the second and third columns of the above table against the year 1887.

Revaccination in the Army and Navy.

The next question discussed is that of the influence of revaccination in the army and navy. The figures given in the Commission's tables are sufficiently striking to afford very strong evidence of the value of revaccination. The writer of the present article, however, is inclined to think that the percentage of unsuccessful revaccinations performed in the army and navy might be considerably reduced. It is true that the rule is to repeat the attempt at revaccination a second or even a third time or possibly oftener, but there appears no sufficient record of the percentage of failures after these repetitions. On the whole, it seems very doubtful whether revaccination is prosecuted in the army and navy with the same insertion success which is experienced in operating on the staff of small-pox hospitals. In these the records are so well kept that in nearly every case of small-pox it can be shown whether the person had escaped revac-

cination or had had the operation unsuccessfully performed. The army and navy furnish no quite equivalent records, though in the Local Government Board's report for 1884 Sir George Buchanan wrote with reference to a Parliamentary Return obtained by Mr. Burt, M.P.: "As regards small-pox in the navy, the 43 deaths shown by Mr. Burt's return to have occurred in that service in the eleven years following the order of 1871 are found, on reference to the reports of that department, to be made up of 13 persons who were vaccinated once and once only; of 12 persons (including 11 Kroomen) who had never been vaccinated at all; of 12 persons (including 2 foreigners) about whom no information was to be had; and of 6 persons who had presumably been successfully vaccinated and revaccinated. These were the small-pox deaths occurring during eleven years, on a mean strength of nearly 60,000 men."

The Army.

The following is the first table given by the Commission and refers to the troops in the United Kingdom from 1847 to 1894. It is necessary in reading it to keep in mind that the practice of vaccination of recruits on joining began in 1858 and that during the years following as men previously recruited passed out of the army the proportion of the vaccinated strength increased until in about ten years there were few of the earlier recruits left:

At Home.

Year.	Attacks of Small-pox to every 10,000 of the Strength.	Deaths from Small-pox to every 10,000 of the Strength.	Year.	Attacks of Small-pox to every 10,000 of the Strength.	Deaths from Small-pox to every 10,000 of the Strength.
1847...	18	1.0	1871...	23.0	2.3
1848...	26	1.6	1872...	14.0	1.4
1849...	25	3.2	1873...	1.0	0.1
1850...	14	0.7	1874...	1.0	0.0
			1875...	0.6	0.1
1851...	14	0.8	1876...	3.0	0.2
1852...	30	2.1	1877...	3.0	0.4
1853...	20	2.2	1878...	2.0	0.1
1854...	41	4.5	1879...	1.0	0.0
1855...	47	3.8	1880...	0.4	0.0
1856...	12	0.4			
1857...	12	1.0	1881...	3.0	0.2
1858...	32	1.8	1882...	2.0	0.1
1859...	24	1.0	1883...	1.0	0.0
1860...	14	0.7	1884...	1.0	0.0
			1885...	2.0	0.3
1861...	6	0.4	1886...	1.0	0.0
1862...	8	0.4	1887...	1.0	0.1
1863...	16	0.8	1888...	1.0	0.1
1864...	15	1.4	1889...	0.2	0.0
1865...	12	0.8	1890...	0.0	0.0
1866...	5	0.1			
1867...	5	0.1	1891...	0.1	0.0
1868...	9	0.3	1892...	6.0	0.0
1869...	1	0.0	1893...	0.8	0.0
1870...	3	0.1	1894...	1.0	0.0

In the Colonies.

Year.	Attacks of Small-pox to every 10 000 of the Strength.	Deaths from Small-pox to every 10,000 of the Strength.	Year.	Attacks of Small-pox to every 10,000 of the Strength.	Deaths from Small-pox to every 10,000 of the Strength.
1860...	8.0	1.0	1878...	1.0	0.4
			1879...	0.3	0.0
1861...	12.0	0.9	1880...	2.0	0.4
1862...	15.0	2.3			
1863...	5.0	0.0	1881...	0.0	0.0
1864...	16.0	1.5	1882...	1.0	0.0
1865...	12.0	1.1	1883...	3.0	0.0
1866...	7.0	0.0	1884...	0.5	0.0
1867...	8.0	0.0	1885...	1.0	0.0
1868...	10.0	0.3	1886...	0.0	0.0
1869...	4.0	0.0	1887...	1.0	0.0
1870...	8.0	1.3	1888...	3.0	0.0
			1889...	2.0	0.0
1871...	51.0	7.0	1890...	0.0	0.0
1872...	0.5	0.0			
1873...	3.0	0.5	1891...	2.0	0.0
1874...	2.0	0.0	1892...	0.0	0.0
1875...	5.0	0.0	1893...	2.0	0.0
1876...	0.0	0.0	1894...	1.0	0.0
1877...	0.4	0.0			

The preceding table shows the attack-rate of, and mortality from, small-pox among the British troops in the Colonies from the year 1860 onwards:

In India.

The following table shows the attack-rate of, and mortality from, small-pox amongst the British troops in India during the same period:

Year.	Attacks of Small-pox to every 10,000 of the Strength.	Deaths from Small-pox to every 10,000 of the Strength.	Year.	Attacks of Small-pox to every 10,000 of the Strength.	Deaths from Small-pox to every 10,000 of the Strength.
1860...	25	2.9	1878...	12	2.3
			1879...	6	0.6
1861...	40	6.1	1880...	1	0.2
1862...	6	0.8			
1863...	8	1.8			
1864...	21	2.9	1881...	3	0.2
1865...	21	2.6	1882...	8	0.7
1866...	6	1.0	1883...	19	1.6
1867...	8	0.9	1884...	14	1.4
1868...	8	0.0	1885...	2	0.0
1869...	28	3.2	1886...	4	0.2
1870...	4	0.9	1887...	6	0.3
			1888...	15	1.5
1871...	2	0.2	1889...	22	2.5
1872...	9	1.9	1890...	5	0.6
1873...	14	1.9			
1874...	8	1.3	1891...	2	0.2
1875...	2	0.3	1892...	3	0.4
1876...	3	0.0	1893...	5	0.6
1877...	7	0.3	1894...	2	0.4

In Egypt.

The following table shows the attack-rate of, and mortality from, small-pox amongst the British troops in Egypt during the years from 1882 onwards:—

Year.	Attacks of Small-pox to every 10,000 of the Strength.	Deaths from Small-pox to every 10,000 of the Strength.	Year.	Attacks of Small-pox to every 10,000 of the Strength.	Deaths from Small-pox to every 10,000 of the Strength.
1882...	5	0.0	1889...	122	17.5
1883...	10	3.8	1890...	0	0.0
1884...	39	1.5			
1885...	54	4.2	1891...	3	0.0
1886...	46	2.7	1892...	6	0.0
1887...	49	7.6	1893...	8	0.0
1888...	42	12.0	1894...	0	0.0

The Troops in India and Egypt.

It will be observed that there were more cases of the disease among the forces in India and Egypt than elsewhere. This is due to the fact that in India and Egypt there is much more small-pox among the native populations, and therefore much greater opportunity of infection. In Prussia an exactly parallel experience has been pointed out by Dr. Edwardes. Revaccination was compulsory in the army there and appears to have been very well enforced previous to its being also made compulsory in the general population. The army records now show that even the exceedingly trivial number of cases of small-pox which occurred among the troops prior to general revaccination of the whole community have now practically disappeared since national revaccination came into force. Not only is the army revaccinated, but it lives in a revaccinated country, and each individual, in addition to the direct benefit of his own revaccination, has the general benefit of the revaccination of the surrounding community.

The Navy.

Turning from the army to the navy, the table on p. 81 has to be read in connexion with the fact that the practice of vaccinating every person entering the service other than natives joining abroad dates from April, 1864. There had, of course, been much vaccination before that time, but there was no regulation, and it took a number of years before the practice begun in 1864 could have its full effect. Even after that date there was for some time no regulation enforcing the

vaccination of foreigners and of natives engaged abroad and discharged before the return of the ship from her station. These have been included in an order only since 1873.

Year.	Attacks of Small-pox to every 10,000 of the Force.	Deaths from Small-pox to every 10,000 of the Force.	Year.	Attacks of Small-pox to every 10,000 of the Force.	Deaths from Small-pox to every 10,000 of the Force.
1860...	51	3.9	1878 .	2 0	0.0
			1879...	12.0	3.1
1861..	50	3.8	1880...	2.0	0.2
1862...	17	3.1			
1863 .	22	2.8	1881...	6.0	0.7
1864...	87	6.2	1882...	2 0	0 5
1865...	32	2.9	1883 ..	2 0	0 0
1866 .	48	1.6	1884...	1 0	0.0
1867...	49	2.7	1885...	1.0	0 0
1868...	16	0.4	1886...	2.0	0.6
1869...	17	1.0	1887..	0 2	0.0
1870...	9	0.2	1888...	4 0	0.2
			1889...	1.0	0.2
1871...	31	2.5	1890 .	1.0	0 4
1872...	19	2.3			
1873...	3	0.2	1891 ..	3.0	0 0
1874...	2	0 2	1892...	2.0	0 3
1875...	4	0.2	1893 .	1.0	0.0
1876..	5	1 3	1894 ..	3.0	0.0
1877...	4	0.0			

The Postal Service.

Concerning the postal service, Sir Charles Dilke, a member of the Government of that time, spoke thus in 1883:

In the case of persons permanently employed in the postal service in London, averaging 10,504, who are required to undergo vaccination on admission, unless it has been performed within seven years, there has not been a single death from small-pox between 1870 and 1880, which period included the small-pox epidemic, and there have been only 10 slight cases of the disease. In the telegraphic department, where there is not so complete an enforcement of vaccination, there have been only 12 cases in a staff averaging 1,500 men.

The Commission give the following additional figures:

Year.	General Post Office.		
	Number of Established Officers Employed.	Number of Cases of Small-pox.	Number of Deaths from Small-pox.
1891	47,264	None	None.
1892	54,198	2	None.
1893	58,311	4	None.
1894	60,490	11	1

And then they add:

It is noteworthy that, in the year 1892, 12 officers were absent from duty on account of the presence of small-pox in their houses; in 1893, 44; and in 1894 as many as 53.

The Commission's Conclusion.

The Commission, in summing up the evidence regarding revaccination in this country find that the particular classes revaccinated—the postal and police services, the army and navy, and the small-pox hospital nurses—"have exhibited a position of quite exceptional advantage in relation to small-pox, although these classes have in many cases been subjected to special risk of contagion." They find also

that in the population at large revaccinated persons seem to be in a position much more advantageous not only than the unvaccinated, but than adults who have only been vaccinated in infancy.

Further:

Where revaccinated persons were attacked by or died from small-pox, the revaccination had for the most part been performed a considerable number of years before the attack.

From this they infer that persons specially exposed to contagion should be revaccinated, and that even those who have been twice vaccinated with success should, if specially exposed, have the operation repeated if a long interval has elapsed since the last operation.

Revaccination Abroad.

The Commission then refer very shortly to the evidence regarding revaccination obtainable from foreign countries.

In the French and German Armies.

The question of the relative prevalence of the disease in the French and German armies during the epidemic of 1870-71 has often been referred to in vaccination polemics in this country, and antivaccinists have made much of the fact that the authenticity of certain statistics had not been proved. On this subject, therefore, it seems desirable to give in full the conclusions arrived at by the Royal Commission.

A comparison of the mode in which the very general small-pox epidemic of 1870-71 affected the German and French armies in those years is especially worthy of attention. In the year 1834 vaccination was made compulsory for soldiers in the Prussian army. Although it may not have been enforced with complete thoroughness, there seems to be no doubt that the German army was, on the whole, a well-vaccinated class at the time of the campaign of 1870-71. We do not think there can be any real doubt that the French army was, during the same period, in a condition in that respect less satisfactory. According to the official returns, the number of small-pox deaths in the German forces during the years in question was only 316. It was stated by Monsieur de Freycinet, when Minister of War, that 23,400 French soldiers died of small-pox during the years 1870-71. We have not been able clearly to ascertain how these last figures were procured. They were not derived directly from any official return. It would seem that the average derived from a limited number of returns relating to particular portions of the army was applied to the army as a whole. It is quite possible, therefore, that the figures given may not be accurate, and that the number stated is in excess of the real number of deaths; but we do not think it is possible to doubt that the ravages of small-pox in the French army were very great, and that the mortality was enormously in excess of that suffered by the force which was opposed to them. Various facts which have been deposed to—as, for example, the small-pox deaths in the ranks of the French soldiers imprisoned in Germany—confirm this view, which receives further confirmation from a comparison of the small-pox deaths in the French and Prussian armies in the time of peace which immediately preceded the war. In 1869 there were 63 deaths from small-pox in the various French garrisons. In the four years from 1866 to 1869 there were 380 deaths from small-pox, 323 of them being in the active army. On the other hand, the total number of deaths from small-pox in the Prussian army from 1835 to 1869 was but 77.

In Prussia and Austria.

A table is given of the small-pox mortality in Prussia and Austria from 1862 to 1881 in order to show the influence of the Prussian revaccination law of 1874. These figures, however, have so often been referred to in the BRITISH MEDICAL JOURNAL that we do not quote them.

Cow-pox and Small-pox.

The Commission now enter on a brief discussion of the theoretical consideration relating to the nature of cow-pox and small-pox and their relation to each other, but we do not give any account of it here.

Summary: the Protective Power of Vaccination.

This is followed by a short summary of the evidence as to the protective influence of vaccination. It is pointed out that in all countries the introduction of vaccination has been immediately followed by marked though irregular diminution of small-pox mortality; that there has been in the United Kingdom a remarkable change in the age-incidence of small-pox only accountable for by vaccination; that the fatality of small-pox is far less in the vaccinated than in the unvaccinated; that this difference in fatality is much more marked in the first ten years of life; that the type of disease is more favourable in the vaccinated than in the unvaccinated; that liability to attack by small-pox is less in the vaccinated than in the unvaccinated, this also being specially noticeable under 10 years old; that the protection of vaccination appears greatest where the operation has been most thorough; that the revaccination of adults gives them special protection; and that "investigations which have followed so many different roads have all led to the same end," and that "it has appeared to us impossible to resist the conclusion that vaccination has a protective effect in relation to small-pox." The details of the conclusions arrived at have already been quoted in this article.

Injurious effects alleged to result from vaccination and the means to be adopted for preventing or lessening these effects is the

next subject considered by the Commission. Since 1896, however, the practical abandonment of humanized lymph and the universal resort to calf lymph has so altered the question that the Commission's Report is now of little more than historical interest. Briefly, their conclusion with reference to humanized lymph is that "although some of the dangers said to attend vaccination are undoubtedly real and not inconsiderable in gross amount they are insignificant," and that "there is further reason to believe that they are diminishing under the better precautions of the present day, and with the addition of the further precautions which experience suggests will do so still more in the future."

The last subject reported on is: *As to what means, other than vaccination, can be used for diminishing the prevalence of small-pox, and how far such means could be relied on in place of vaccination.*

Two groups of means are considered: (1) Measures directed against infection, for example, prompt notification, isolation of the infected, disinfection, etc. (2) Measures calculated to promote the public health, the prevention of overcrowding in dwellings or on areas, cleanliness, the removal of definite insanitary conditions, etc.

Isolation.

A short historical account is given of proposals for isolation as a small-pox preventive, and of the influence of isolation as practised, and of the influence of small-pox hospitals on the spread of the disease in populations in the immediate neighbourhood. The conclusion arrived at is as follows:

We think that a complete system of notification of the disease, accompanied by an immediate hospital isolation of the persons attacked, together with a careful supervision, or, if possible, isolation for sixteen days of those who had been in immediate contact with them, could not but be of very high value in diminishing the prevalence of small-pox. It would be necessary, however, to bear constantly in mind as two conditions of success, first, that no considerable number of small-pox patients should ever be kept together in a hospital situate in a populous neighbourhood, and, secondly, that the ambulance arrangement should be organized with scrupulous care. If these conditions were not fulfilled, the effect might be to neutralize or even do more than counteract the benefits otherwise flowing from a scheme of isolation.

No Substitute for Vaccination.

That conclusion, however, does not contemplate isolation as a substitute for vaccination but only as a supplement to it, and the evil influence of small-pox hospitals considerably complicates the question in its present-day aspects. Even without our recent knowledge on this subject the Commission write:

We can see nothing, then, to warrant the conclusion that in this country vaccination might safely be abandoned and replaced by a system of isolation. If such a change were made in our method of dealing with small-pox, and that which had been substituted for vaccination proved ineffectual to prevent the spread of the disease (it is not suggested that it could diminish its severity in those attacked), it is impossible to contemplate the consequences without dismay.

To avoid misunderstanding, it may be well to repeat that we are very far from under-rating the value of a system of isolation. We have already dwelt upon its importance. But what it can accomplish as an auxiliary to vaccination is one thing, whether it can be relied on in its stead is quite another thing.

Common Lodging-houses.

They also make a series of useful recommendations for the prevention of small-pox being spread through the inmates of common lodging-houses. These are as follow:

1. That common shelters which are not now subject to the law relating to common lodging-houses should be made subject to such law.

2. That there should be power to the local authority to require medical examination of all persons entering common lodging-houses and casual wards to see if they are suffering from small-pox, and to offer a reward for prompt information of the presence of the disease.

3. That the local authority should have power to order the keeper of a common lodging-house in which there has been small-pox to refuse fresh admissions for such time as may be required by the authority.

4. That the local authority should be empowered to require the temporary closing of any common lodging-house in which small-pox has occurred.

5. That the local authority should have power to offer free lodgings to any inmate of a common lodging-house or casual ward who may reasonably be suspected of being liable to convey small-pox.

6. That the sanitary authority should give notice to all adjoining sanitary authorities of the occurrence of small-pox in common lodging-houses or casual wards.

7. That where the disease occurs the public vaccinator or the medical officer of health should attend and vaccinate the inmates of such lodging-houses or wards, except such as should be unwilling to submit themselves to the operation.

The Local Authority for Vaccination.

Concerning the proper authority for administration of the Vaccination Acts the Commission say: "Indeed the advantage of placing in the same hands the supervision of vaccination and of the other measures designed to prevent the spread of the disease are so great and so obvious that the proposal to do so deserves most serious consideration. Under present arrangements, however, such a proposal raises very great difficulties and would be impracticable without a complete recast of our present areas of local administration" but, they add—

At the same time we fully recognize the importance of achieving it as far as possible and we should regard with favour such changes as would render the amalgamation of the vaccination and sanitary authorities feasible, or indeed any steps taken in that direction even although they should only partially effect the object in view.

The final question considered by the Commission is: *As to whether any alterations should be made in the arrangements and proceedings for securing the performance of vaccinations, and, in particular, in those provisions of the Vaccination Acts with respect to prosecutions for non-compliance with the Law.*

Vaccination not really Compulsory.

They point out to begin with that though vaccination is often spoken of as compulsory in this country, it has never been so, payment of a fine having always been sufficient to meet the requirements of the law. Nor do they think that absolute compulsion would be possible nor even that more stringent punishment such as imprisonment would be useful.

The Commission's Object.

The question, they say, is, What form of law, based on penal provisions of this description, will secure the largest number of vaccinated persons? It is to be clearly borne in mind that the recommendation of the Commission as to a relaxation of the law had no other purpose in view than is indicated here. They state their belief that objection to vaccination "has largely risen from the attempt to compel parents to vaccinate their children who conscientiously believe that vaccination is of little or no advantage as a protection against small-pox, and that it involves a serious risk of injury to the health of the vaccinated child."

It was in order to foster vaccination that the Commission recommended in their fifth Report—a short document which was specially issued a considerable time before the final Report—that repeated penalties should be abolished:

The penalty was not designed to punish a parent who may be considered misguided in his views and unwise in his action, but to secure the vaccination of the people. If a law less severe, or administered with less stringency, would better secure this end, that seems to us conclusive in its favour.

The Commission do not think it impossible to devise a scheme "which would preclude the attempt—so often a vain one—to compel those who are honestly opposed to the practice to submit their children to vaccination, and, at the same time, leave the law to operate, as at present, to prevent children remaining unvaccinated owing to the neglect or indifference of the parent."

Conscientious Objection.

They accordingly recommend that the parent might attend before the local authority, and satisfy them of the genuineness of his objection, or that a statutory declaration might be made before any one authorized to take such a declaration. They do not believe that in practice this would be a retrograde course as to vaccination, but at the same time they think that the change should be a temporary one in the first place, say, for a period of five years, and that its effects should be carefully watched. The Scotch system of domiciliary vaccination should at the same time be introduced, as in Scotland there is little opposition to the law.

Private and Public Vaccination.

Further, they

think it would tend to promote vaccination if every duly qualified medical man who vaccinated a child successfully were entitled to the fee which is now paid only to the public vaccinator.

But that

the fee should only be allowed in cases where the certificate showed that the child had been vaccinated in accordance with the rules prescribed by the Local Government Board. And if every duly qualified practitioner who vaccinated a child successfully could claim the appointed fee, it could properly and ought, we think, to be made a condition that all children so vaccinated should be liable to inspection, and that the fee should not be allowed when the examination did not appear to have been performed in accordance with the prescribed rules. It would not, of course, be necessary to make such an inspection in every case; a limited number of test cases would suffice. The liability to inspection would prevent abuse, and under proper regulations we think the system might be an improvement on any at present existing.

Compulsion as to Revaccination.

Concerning revaccination, while fully agreeing as to its importance they think that there would be practical difficulties in its enforcement, but that it should be encouraged, and an additional fee allowed for every case by whatever medical man it was performed, and that "when small-pox shows signs of becoming epidemic special facilities should be afforded both for vaccination and revaccination."

Notification of small-pox should be compulsory, and attention should be called to the importance of avoiding contact with small-pox patients.

This concludes our synopsis of the Final Report. We do not propose to summarize the Appendix in which the Commission discuss in fuller detail (*a*) the variolous test, and (*b*) Woodville's cases, nor the Statement of Dissent by Dr. Collins and Mr. J. A. Picton, which has been fully reviewed in the *Transactions of the Epidemiological Society* for 1896-7.

Printed and published by the British Medical Association at their Office, No. 429, Strand, in the Parish of St. Martin-in-the-Fields, in the County of Middlesex.