In the discussion one of the members stated that another sample, drawn from the same locality but at a different time, was found by him to be of normal composition.

*On the Relation of the Specific Gravity of Urine to the Solids Present:* J. H. LONG. (By title.)

*Cereal Foods:* EDWARD GUDEMAN.

Analysis of a large number of samples from forty-three different manufacturers shows an average composition of

| | |
|---|---|
| Ash | 0.3 |
| Fiber | 0.5 |
| Fat | 0.7 |
| Proteids | 10.5 |
| Carbohydrates (by difference) | 88.0 |
| | 100.0 |

*The Determination of Starch:* W. A. NOYES and R. B. ARNOLD.

One of the objects of this work was to determine the best conditions for hydrolysis. One hour is the most favorable length of time with 0.5 per cent. acid at a temperature of 100°, or half an hour at 111°. Solutions giving 2 per cent. glucose give better results than those giving 0.5 per cent. glucose. In neutralizing the acid, it is much more desirable to stop a little short of the exact point rather than to overstep it. The greatest hydrolysis that could be obtained was 96–99 per cent. of the theoretical.

AUSTIN M. PATTERSON.

## *THE CASE FOR VACCINATION.*

THE recent appearance of an admirable book entitled 'A Concise History of Smallpox and Vaccination in Europe,' by Edward J. Edwardes, has aroused new enthusiasm among British sanitarians in their efforts to undo the evil effects of the last Vaccination Act, which permitted the exemption of those persons known as 'conscientious objectors.' Its lesson is equally salutary in this country, where the vaccination laws are at present far too lax, and where the opponents of vaccination are conducting an active campaign for their repeal.

It should be frankly acknowledged that the responsibility incurred by the state in compelling its citizens to submit to the introduction of vaccine matter is a grave one. It is, in the first place, a serious infringement of personal liberty; and, in the second place, it must be owned that the process is attended with a certain, though an almost inappreciable, amount of danger. When arm-to-arm vaccination was practised, loathsome diseases were occasionally conveyed from one human being to another, but the general introduction of calf lymph now prevents the possibility of any such contingency. The transmission of tuberculosis, too, is effectually precluded by the tests to which the calves are submitted and by the addition to the lymph of glycerin. Erysipelas and tetanus, on the other hand, still sometimes follow vaccination. In a very large majority of cases these complications are due to secondary infection by the removal of dressings from the vaccination wound; in a few instances they have been traced to infection of the lymph itself. The extent of these dangers is, however, very slight. Dr. McFarland* in a careful review of all previous medical literature, was last year only able to find 95 cases of tetanus recorded as due to vaccination. The total number of deaths from erysipelas in the United States in 1900 was 2,861, and the total number from tetanus, 1,664, in a population of 75,994,575 with 1,039,094 deaths from all causes; and it can scarcely be claimed that any large proportion of this insignificant number was due to vaccination.

On the other hand, the benefits which

* 'Tetanus and Vaccination,' *Journal of Medical Research*, VII, 1902, p. 474.

vaccination has bestowed upon the human race may best be estimated by comparing the popular dread of smallpox prior to 1800 with the indifference with which it is regarded now. The 'Concise History,' referred to above, begins with a series of citations from the earliest medical writers, and we note that Rhazes, in the tenth century, attempted to explain how it happened that scarcely any one could escape the disease, and Mercurialis (born in 1530) said that 'almost every person must have it once.' In the eighteenth century statistics first became available from the works of Süssmilch, De la Condamine and others. The most important are those of Sweden, where in the period from 1774 to 1800 the annual smallpox death rate averaged 2,049 per million living and accounted for about one thirteenth of the total deaths from all causes. The statistics for Copenhagen, for London, for Berlin, for Liverpool and for Glasgow show in general the same relations, although in the latter city from 1783 to 1800 smallpox caused nearly one fifth of the total deaths. Nine tenths of the fatal cases of smallpox occurred in children under ten years of age.

Towards the end of the eighteenth century the struggle against this dread disease seemed almost hopeless. The practise of inoculation, which consisted in the introduction of actual smallpox matter under the skin, in order to induce a mild attack at a time when the body was in condition to meet it, had failed to effect any reduction in the general death rate. Just when it seemed that 'the continued raging of that pitiless plague' was the only prospect for mankind, Edward Jenner proved that an attack of the mild disease of cattle known as cowpox furnished protection against infection with the smallpox. He suggested 'vaccination' with cowpox material as a simple prophylactic against smallpox, and it is the introduction of this process which Dr. Edwardes calls 'the greatest sanitary fact which the world has ever known.' It was in June, 1798, that the physician of Gloucestershire published his 'Inquiry into the Causes and Effects of the Variolæ Vaccinæ,' and by 1801 it had been translated into Latin, German, French and Dutch. "As if an angel's trumpet had sounded over the earth, thus spread the good tidings into all lands, that a preventive had been found against the horrible disease smallpox, so long the scourge of humanity."

The protective effect of vaccination was at once established by actual experiment, and on a very large scale, by inoculating those who had been vaccinated with the true smallpox virus. Woodville stated in 1802 that of 7,500 persons vaccinated at the smallpox hospital, about one half had been since inoculated, without any effect being produced. Dr. Charles Creighton and Alfred Russel Wallace, the chief authorities of the 'anti-vaccinationists,' have attempted to discredit these tests by claiming that Woodville's lymph was contaminated and that the vaccination was really inoculation in itself. It is amusing to note that Wallace adopts this explanation on page 8 of his 'Vaccination a Delusion,' and on page 76 of the same book seriously maintains not only that vaccination exercises no protective effect, but that after a previous attack of smallpox 'instead of there being any immunity, there is really a somewhat increased susceptibility to a second attack.' It is odd that this startling fact was not noticed in the days when every one had the smallpox at least once! Woodville's account of his experiments shows that only a very small proportion of his cases—and those all prior to June, 1799—lay open to the objection mentioned above, and his conclusions were confirmed by similar tests, notably by 8,000 cases treated at the Medical College in Berlin. A small but

well-controlled experiment was carried out at Milton, Massachusetts, in 1809, with the same result.

The statistics of the early part of the nineteenth century furnish the first evidence of the effect of vaccination as applied upon a large scale. In Sweden, for example, the average annual smallpox rate per million was 1,914 from 1792 to 1801, 623 from 1802 to 1811, and 133 from 1812 to 1821. In Berlin the actual deaths from the disease amounted to 4,453 for the ten years 1782–91, 4,999 for the next decade, 2,955 for 1802–11, and 555 for 1812–22. The facts are brought out in a still more striking manner when the figures are plotted graphically, as was done for London from 1650 to 1900 by Dr. Newsholme.* Wallace published a similar diagram of the Swedish death rates which is alone enough to convince a candid student that something remarkably affected smallpox mortality about 1800; but he closed his eyes to its obvious teaching, and maintained that inasmuch as the curve fell off sharply from 1800 to 1803 before vaccination had become general, the decrease was due not to vaccination, but to 'sanitation.' It is certainly true that the deaths from smallpox decreased in the two or three years after 1800 without reference to vaccination, just as they had decreased periodically after every epidemic in the eighteenth century. But after every such previous decrease the mortality had risen again within five or ten years to another maximum. Why, after the decrease in 1803, did the death rate in Sweden remain at a minimum, never having risen since 1809 over 1,000 per million, and but four times over 500, while in 1801 it was 2,566, in 1800 5,126, in 1799 1,609, in 1796 1,963 and in 1795 2,956? There is not the smallest shred of evidence that 'sanitation' received any great and sudden impetus at exactly this time, unless sanitation be used to cover all the arts which tend toward 'the prevention of premature death.' In this wholly legitimate sense sanitation includes a number of prophylactic measures, each adapted to the diminution of a specific disease. When sanitation covered only isolation and quarantine it could control plague to a certain extent, but not smallpox, not typhoid fever, not diphtheria, not measles. When vaccination became a sanitary measure, sanitation conquered smallpox; but typhoid fever was not restricted until the day of water supplies and sewerage systems; diphtheria, not until the introduction of antitoxin. A fairly steady decrease in the general death rate has, indeed, occurred, due to a complex of factors not easily analyzed, but a sudden collapse such as that which affected the smallpox death rate after 1800 has never been manifest without a definite and tangible cause. That 'sanitation' has not affected the other zymotics to the same degree as smallpox has been graphically shown by A. F. Burridge in a recent publication.*

During the first quarter of the nineteenth century it was thought that a single vaccination in infancy would give indefinite protection against smallpox; but about 1830 this view began to lose ground. An adult population now existed, protected, not, as in other times, by previous attacks of smallpox, but only by the less potent effect of vaccination. Smallpox began, therefore, to recur, but modified in two notable respects. In the first place, its age incidence had shifted; whereas of 1,252 cases in three Prussian towns before vaccination began, 94.5 per cent. were under ten and not one over twenty years; of 1,677 cases in Wür-

* 'The Epidemiology of Smallpox in the Nineteenth Century,' *British Medical Journal*, July 5, 1902.

* 'Vaccination and the Act of 1898,' *Journal of the Institute of Actuaries*, October, 1902.

temberg after vaccination began, 18.4 per cent. only were under 10, and 42 per cent. over twenty years. So it is shown by Dr. Creighton in his article on 'Vaccination' in the 'Encyclopedia Britannica,' that, in England and Wales, about 1847, three fourths of the deaths occurred under five years, while in the eighties less than a quarter of the decedents were of this age. In the second place, beside this shifting of incidence, smallpox among the vaccinated proved much less fatal, even when it was contracted, than among the unvaccinated.

Although minor epidemics began to recur, smallpox in vaccinated countries was insignificant in amount until 1870–5, when a 'pandemic' swept over Europe which recalled the normal conditions of the pre-vaccination period. Considering the varying virulence of disease at different periods, and the fact that the importance of revaccination was not at all realized, such an epidemic was to be expected. The statistics for the early seventies have been used most dishonestly by the anti-vaccinationists in comparison with selected years of low mortality immediately after the introduction of vaccination in the attempt to show that no progress has been made. The worst year of this period in England and Sweden, however, showed a death rate about half the average yearly rate for the last quarter of the eighteenth century.

A comparison of the incidence of smallpox in this pandemic of 1870–5 upon different countries introduces the second class of evidence as to the value of vaccination. Thus Dr. Edwardes shows that for four countries having compulsory vaccination the average yearly smallpox death rate per million inhabitants was as follows: England, 361; Scotland, 314; Bavaria, 346; Sweden, 333. On the other hand, the rate for the same period was 953 in Prussia, 1,360 in Austria, 1,293 in Belgium and 958 in the Netherlands. All these countries had at this time no compulsory vaccination. The reverse has been affirmed in the case of Prussia, and Creighton, in the 'Encyclopedia Britannica,' states that revaccination 'has been more or less the law in Prussia since 1835,' and that 'Prussia was the best revaccinated country in Europe' in 1871. Dr. Edwardes discusses this question in some detail and quotes the official documents, which show explicitly that there existed in Prussia 'kein gesetzlicher Zwang zur Impfung.' Furthermore, the actual ratio of vaccination to births in Berlin is on record, and the percentage ranged from 29 to 58 between 1865 and 1870. In this city there were 6,326 smallpox deaths per million living in 1871!

The 'great pandemic' taught the lesson that both vaccination and revaccination were essential. In 1874 Germany enacted a law providing for compulsory vaccination within the second year and revaccination within the twelfth year. In Prussia the death rate, which had ranged from 95 to 2,624 per million from 1866 to 1874, dropped to 36 in 1875 and has been under 10 since 1885. For the empire as a whole, statistics, available only since 1886, show a rate of 4.2 in that year, decreasing to .5 in 1895 since which there has been annually less than one death per million. A comparison with the statistics of Austria graphically made by Dr. Edwardes furnishes as striking a proof that vaccination is the only kind of sanitation which affects smallpox as could well be desired. Before 1870 the two countries had about the same amount of smallpox; since 1875 that in Austria has increased and that in Prussia has practically disappeared. The only difference in conditions lies in the law of 1874.

Army statistics furnish striking confirmatory evidence. Thus Burridge* compares

* *Loc. cit.*

the Prussian army, in which revaccination on entrance has been compulsory since 1834, with the French army, where it has only been thoroughly carried out since 1888, and with the Austrian army, where there was no revaccination prior to 1886. The attack rate per 100,000 in 1875–85 was 4.7 in the Prussian army, 133.6 in the French army and 333.7 in the Austrian army. In the twenty-five years 1875–99 there were only two deaths from smallpox in the Prussian army, one in 1884 and one in 1898. The main point to notice is that these extraordinary results have been attained by a general revaccination of the whole population. Revaccination of only a single class in the community can not prevent the occurrence of occasional cases in that class, because in a large body of men there must always be some vaccinations which have not been successful. Thus the smallpox death rate in the English army with revaccination has ranged from zero to twenty-nine during the last forty years. Wallace in 'Vaccination a Delusion' made these figures look larger by raising them to rates per million (the basis of calculation being about 200,000 men), and then compared them with the rates for Ireland at the age period 15 to 45, which were only slightly higher from 1864 to 1894 (58 for the army, 65.8 for Ireland). Later he showed that the rate for 1873–94 was 37 in the army, 36.8 in the navy and 14.4 in the city of Leicester, and concluded that 'all the statements by which the public has been gulled for so many years as to the almost complete immunity of the revaccinated army and navy are absolutely false.' 'There is *no* immunity. They have *no* protection.' That is, Mr. Wallace selects one island in Europe where, largely from its isolation, smallpox happens not to have been serious, and one town in England where there has been almost no smallpox, and because these two places have had extraordinarily low death rates he maintains that the low army death rate, indicates no protection! Yet the figures were before him which showed that the average of the annual death rates in the navy, which was less than 32 from 1873 to 1899, had been 257 from 1860 to 1873; in 1873 an order was issued which provided for the vaccination of all recruits on joining.

The evidence derived from a comparison of the same country before and after the introduction of vaccination, and that based on the contrast at the same period between countries having different degrees of vaccination, have now been briefly considered. The third class of facts includes the 'direct evidence' of the incidence of smallpox upon persons in the same community protected and unprotected by vaccination. At Chemnitz in 1870–1, a special census was made to determine the condition of the population as regards vaccination, and it appeared that among those protected by vaccination or previous smallpox the death rate was 1.2 per 10,000, while in the unprotected it was 442.9. Similarly at Sheffield in 1887–8* the deaths per 10,000 were 7.5 among the vaccinated and 347.9 among the unvaccinated. An objection to statistics of this sort, made with some plausibility, is that the unvaccinated class includes a large proportion of children and of persons in feeble health or living under poor sanitary conditions. Regarding the first point, the Sheffield figures are conclusive. They are divided according to age periods and show that the rates per 10,000 living between fifteen and twenty years were, 7.0 in the vaccinated and 1,355.5 in the unvaccinated. Here no age difference comes in question. The second contention is met by the statistics collected by Körösi with reference to 14,678 persons dying from various causes in some Hungarian hospitals in 1886. The unvaccinated constituted 14

* Reviewed by Burridge, *loc. cit.*

per cent. of those who died from other diseases than smallpox and 81 per cent. of those who died from smallpox. Obviously it was the lack of vaccination which was at fault here, not feeble health nor unsanitary conditions. In opposition to these figures the anti-vaccinationists quote the experience of the city of Leicester, where since 1882 the number of vaccinations has steadily decreased, falling to less than two per cent. of the births in some recent years. Smallpox has been introduced a number of times (38 cases in 1892, 308 in 1893, 8 in 1894, 4 in 1895, 4 in 1901), but has not spread extensively, and the death rate has remained very low. The opponents of vaccination also quote, by way of contrast, statistics showing that an increasingly large proportion of hospital cases of smallpox occur among the vaccinated,* and that in epidemics the attack of an unvaccinated person is often not recorded for some time.† Facts of the last two classes have, of course, no special significance except to indicate the need for revaccination. No one now supposes that a single vaccination affords absolute permanent protection, and with the increase of vaccination there must naturally come an increase of cases among the vaccinated. The experience of Leicester, on the other hand, is certainly of interest. It shows that under certain conditions the dangers of neglected vaccination may for a time be braved with impunity by a considerable portion of the community. This has been so far accomplished by prompt reporting and strict isolation of cases, and, according to the chairman of the public health committee of the town by the fact that 'a handful of the population, including the medical men, sanitary staff, smallpox nurses, etc., are as well vaccinated in Leicester as in any other town, so that a cordon of protected persons can at once be drawn around any case of smallpox which may occur.'* It should be remembered, however, that the population of Leicester is still to some extent protected by the vaccinations carried out prior to the anti-vaccinationist agitation. Thus of the 358 persons attacked in 1892–5, 198 were returned as having been at some time vaccinated. The experience of Gloucester is ominous for the future of the 'Leicester experiment.' Prior to 1892–3, according to Dr. Edwardes, 'vaccination had been almost in abeyance, in Gloucester, and the inhabitants lived in a fools' paradise.' The result was an epidemic of 1,979 cases, with 434 deaths in a population of about 40,000, giving a death rate of 10,000 per million!

With regard to the smallpox occurring in persons once vaccinated, there are two points to notice. In the first place, the ratio of deaths to cases is far lower than among the unvaccinated. Thus at the Leipsic city hospital in 1870–2 99 died among 139 unvaccinated cases, 116 died among 1,504 vaccinated cases, and none among 13 revaccinated cases. Creighton and Wallace object to these statistics on the ground that the death rate thus apparent among the unvaccinated is obviously too high, because 'in pre-vaccination times the death rate (18.8 per cent.) was almost the same as it is now in the vaccinated and unvaccinated together' (Creighton. Now it is quite impossible to fix any such general fatality rate; the ratio of deaths to cases has varied within wide limits both in the eighteenth century and recently. In the second place, it has been claimed that the 'unvaccinated' death rate is swollen by the inclusion in that class, of children who escaped vaccination on account of feeble

* London smallpox hospital, 40 per cent. in 1838, $94^{9}/_{10}$ per cent. in 1879—Wallace.

† The first unvaccinated case was the 174th at Cologne in 1870, the 42d at Bonn in the same year, and the 225th at Liegnitz in 1871—Creighton.

* Windley, 'Leicester and Smallpox,' *Journal of State Medicine*, January, 1903, p. 21.

health. In the case of Gloucester, where vaccination has been so generally neglected, this objection can hardly apply. Yet at Gloucester in 1892–3, there were, under ten years of age, 26 attacks among the vaccinated with one death, and 680 attacks among the unvaccinated with 279 deaths. Statistics for six towns collected by the English Royal Commission of 1889 showed fatality rates of 35.4 among the unvaccinated and 5.2 among the vaccinated. The third objection made to the hospital statistics, namely, that the deaths of the unvaccinated class are unfairly increased by the inclusion of doubtful cases and those who have been vaccinated but show no scars, can scarcely apply to the commission's analyses. It will not, at any rate, have much weight, except with those who, like Mr. Wallace, believe that "in this matter of official and compulsory vaccination both doctors and government officials, however highly placed, however eminent, however honorable, are yet utterly untrustworthy."

A second important characteristic of the cases of smallpox in a once vaccinated population is that they are not only comparatively light, but that they affect the later periods of life; and this represents an important gain in the life capital of the community. During the epidemic of 1870–3, Bavaria, with compulsory vaccination, had 851 deaths under, and 3,520 deaths over, twenty years, while the Netherlands without compulsory vaccination had 14,048 deaths under twenty and 6,524 at higher ages. In the same great epidemic 71 per cent. of the deaths at Leicester and 64 per cent. of the death at Gloucester occurred under ten years. In London the percentage falling in this age class was 37, and in Warrington, with still more thorough vaccination, it was 22.5.

A single vaccination then greatly reduces the probability of an attack of smallpox, postpones it to a later period of life and renders it less dangerous if it does ensue. To ensure absolute protection revaccination is required; and its efficacy is well indicated by the experience of the Prussian army. In addition, one single bit of evidence may be adduced which is more striking, perhaps, than all the rest, the statistics of nurses in smallpox hospitals. These figures are of special interest because we have here a fairly large class of persons whose condition as to vaccination is accurately known, and who are uniformly exposed to the contagion of the disease; and the experience of two such communities is quoted by Dr. Edwardes. "During the epidemic of 1871 there were 110 persons engaged in the Homerton Fever Hospital, in attendance on the smallpox sick; all these, with two exceptions, were revaccinated, and all but these two escaped smallpox." "Of 734 nurses and attendants in the Metropolitan Asylums Board Hospitals, 79 were survivors from smallpox attack—they escaped infection; 645 were revaccinated on entrance—they all escaped; 10 were not revaccinated, and the whole 10 took smallpox."

If statistics ever proved anything those quoted above prove the protective influence of vaccination. If any fact in science is certain, it is certain that a successful vaccination absolutely prevents smallpox for a period of some seven to ten years, that after that period it renders the disease less fatal, and that its complete protective effect may be renewed by revaccination. The conclusion is obvious, not only that the state should oblige primary vaccination, but, in the words of a minority of the British Royal Commission, that 'a second vaccination, at the age of twelve, ought to be made compulsory.'

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