child in hospital for two years, nor can it do much harm for children, at the age at which these troubles usually occur, to be deprived of education for a few years.

TUBERCLE VACCINATION : THE PROTECTIVE RÔLE OF THE BOVINE BACILLUS.

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It will be admitted that with a micro-organism so ubiquitous as the tubercle bacillus, we cannot afford to ignore questions of immunization and protection at the same time as we are directing our efforts towards its elimination. The latter goal must still be far from us, and while we are pressing towards it, other issues of importance demand our serious consideration. Of these the most vital to us, living in crowded communities, is the question of acquired immunity from constant slight contact with the germs of disease, and the thesis I propose to defend in the present paper may be shortly stated as follows: That until human sources of infection can be practically eliminated, or artificial immunization becomes an accomplished fact, infection with the bovine bacillus through the use of a well-mixed milk remains our best ally in the campaign against tuberculosis.

This proposition will be best considered under four headings, followed by a short conclusion.

1. *Among Crowded Communities, Infection with the Tubercle Bacillus, whether of Human or Bovine Source, cannot be avoided.*—The high incidence of tuberculosis was first impressed upon the world by the well-known figures of Naegeli of Zurich, but it now appears that a still higher frequency of tuberculous lesions found at autopsy has come to light from still earlier studies—namely, those of Bollinger and Müller for the years 1881 to 1888. They found tuberculous lesions in the following percentage of cases:

Age.	Percentage showing Tuberculous Lesions.
0 to 1 year	12.25
1 to 2 years	28.5
2 to 3 „	36.9
4 to 5 „	61.9
6 to 10 „	40 to 50
10 to 11 „	85.0

These figures come nearer to the modern section statistics of Hamburger and Sluka (Vienna) and of Müller (Berlin); and though it is to

be remembered that this is hospital material, and hence concentrated, it yet paves the way for the startling discoveries of Hamburger and Monti among living people with the more delicate tuberculin reactions. These observers found for Vienna as many as 50 per cent. tuberculous at five years of age, 85 per cent. at ten years, and 94 per cent. at thirteen and fourteen years; and but little lower and in practical correspondence are the figures of Nothmann for Düsseldorf, Mantoux for Paris, Petruschky for Dantzig, Ganghofner for Prague. In this country the figures of Lapage for Manchester and McNeil for Edinburgh do not greatly differ from those found for Continental towns, though the Edinburgh figures present certain peculiarities to be referred to under another heading.

2. *Tuberculous Lesions, and hence Infection with the Tubercle Bacillus, protect the Individual against further Attack, whether from Without or from Within.*—That tuberculous lesions are protective we have ample evidence to show. Artificial immunization against tuberculosis is, unfortunately, not yet with us. Innumerable experiments with bacilli of low or absent virulence have all proceeded to failure, and it appears as if nothing less than a definite tuberculous lesion will afford protection against further infection. For this reason the immunization of cattle with tubercle bacilli of *Typus humanus*, as exemplified in Von Behring's "bovovaccine" or Koch and Schultz's "tauruman," is but of temporary service, the virulence of this organism for adult cattle being too low to provoke tissue-response in the form of tuberculous lesions. There remains the possibility that certain discoveries of Hans Much and Deycke may lead to protection being achieved for humans without the use of living bacilli, but this belongs to the future.

That tuberculous lesions, even when slight and harmless, yet lead to protection against further infection, there is no reason to doubt. Koch's original demonstration that a second inoculation led to local inflammation and necrosis, with elimination of dead material and bacilli, but with no permanent ulceration or glandular disease such as occur to a primary inoculation, has been amply confirmed by Arloing, Römer and Joseph, Calmette and Guérin, and others, and has been shown by Kraus to be applicable to apes, and hence may be fairly presumed for man. Indeed, clinical evidence also points clearly to the presence of such immunity amongst humans. The comparative rarity of intestinal and other tuberculous complications in phthisis may be quoted in support. The protection, moreover, afforded by infection in early life is revealed in many ways. Mayo points out that in Minnesota, where surgical tuberculosis is rife, phthisis is uncommon. Marfan declares that persons with healed tuberculosis of skin and glands never get phthisis. Turban, Weicher, King record the more favourable course of phthisis where a family history of tuberculosis is present, and

the same is the case where the individual has been "scrofulous." The ready curability of phthisis at the age of seven to ten years, remarked on by Hamburger, and well known to all physicians of experience, seems evidence of retention of early immunity to a greater degree than in adults. The same probably accounts to a notable extent for the remarkably low death-rate from tuberculosis of all forms in the later years of childhood, so clearly brought out by the Registrar-General's reports. In putting forward this argument we must not lose sight also of the effect of removal of the susceptible during the high mortality of the first few years of life.

3. *Absence of Acquired Immunity renders the Individual liable at any Age to Acute Forms of Tubercle.*—Absence of acquired immunity must affect two classes of individual—young children and the natives of tubercle-free neighbourhoods. It has been advanced as an interesting problem that young children become infected and immunized with but little disturbance of health, while adults from tubercle-free districts so readily succumb to acute forms of the disease. This is to ignore the enormous mortality from acute tubercle in infancy, the death-rate per million being considerably higher for the age-period under five years than for any other twenty-year period of later life. That most of these deaths are due to infection with the human strain of tubercle bacillus is rendered probable by post-mortem experience; for disease of bronchial glands or lung is present in nearly all such cases, while marked abdominal infection, for which the bovine bacillus is especially responsible, is present in a much smaller proportion, which varies somewhat with locality and observer.

That the absence of acquired immunity may be of serious consequence to adults as well as children is abundantly exemplified by the alarming susceptibility of individuals living in tubercle-free districts. Thus the introduction of tuberculosis into Madeira led to a high mortality among the Portuguese natives, while among the European inhabitants it was but little evident. Metchnikoff, Burnet, and Tarassevitch found that the Kalmucks of the Steppes near the Volga and Caspian Sea coming into the towns died of tuberculosis, so that the girls' school at Astrachan had to be closed, and removal of the boys' school was contemplated. Among such tubercle-free communities acute forms of tubercle, such as are only seen among children in older civilized communities, are common. Thus Westenhoeffer, investigating the conditions in Santiago, Chili, found that among 45 deaths 24 had general miliary tubercle; 28 were chronic, but caseous and with no fibrosis, and 17 showed a caseous pneumonia; 25 cases exhibited intestinal ulceration. Similar conditions as regards form of disease and high mortality-rate were found by Deycke in Turkey, Much in Palestine, Block in Lapland, Wagon in French Guiana, Bernard in

Annam, Peiper in German West Africa, Römer in the Argentine. This last observer has succinctly summed up for us the conclusions to which consideration of Sections 2 and 3 must inevitably lead us. "The less widespread in a community is tuberculosis," he remarks, "the higher is the case mortality"; and farther on comes the striking and significant corollary: "The wider spread is tuberculosis in a community, the smaller the case mortality." It is hard to disagree with these conclusions.

4. *The Bovine Bacillus can afford Protection, and is much less Virulent to Man than the Human Strain of the Tubercle Bacillus.*—That the bovine bacillus can cause tuberculosis in man will not be denied since the findings of the English Royal Commission, the German Imperial Commission, and the exhaustive work done by Weber and others at the Kaiserliche Gesundheitsamt in Berlin. That it can protect against infection with *Typus humanus* is made highly probable by the rarity of phthisis with surgical tuberculosis already referred to. Very significant in this respect also are the figures of McNeil for Edinburgh, where, as shown by Fraser and Philp Mitchell, tuberculosis of bovine origin is particularly rife. Comparing Edinburgh with Vienna, he finds the incidence of tubercle infection higher in the former for children up to the age of four years, and this in itself is highly suggestive of milk infection; but the valuable comment on this is the fact that the mortality from phthisis in Vienna is nearly three times as high as that for Edinburgh. Indeed, the high incidence of abdominal tuberculosis and the low mortality from phthisis is a characteristic of Great Britain as a whole when compared with other civilized countries of Europe, and this may well bear the interpretation that it is the early bovine infection which protects against the inroads of pulmonary tuberculosis caused by the human strain of tubercle bacillus.

That the bovine bacillus is less virulent to man than the human variety is hardly open to doubt. The lesions to which it gives rise are mainly confined to glands in the abdominal and cervical regions of children, and the disease (rare instances of miliary tuberculosis apart) remains, as a rule, localized and recoverable. Practically all the dangerous and fatal forms of tuberculosis—the lung diseases of childhood and phthisis of adults, as well as disease of bones, joints, and thoracic glands to a large extent—are due to the bacillus of human strain. Thus the virulence of the bovine bacillus may be said to be slight for children, while attempts made by Baumgarten to inoculate it into cancerous adults persistently failed. Its comparative avirulence is well exemplified in some investigations published by Weber in 1910, and similar ones by Ungermann in 1912, among infants fed from cows with tuberculous udders. But few of these children developed tuberculosis, and when they did so it was of mild and recoverable type.

This is in striking contrast to the figures of Floyd and Bowditch for children living in phthisical households, among whom a large proportion developed serious lung tuberculosis. Doubtless the different path of infection, respiratory to a large extent on the one hand, and alimentary on the other, must play an important part in the different results of infection through milk and from human sources, since it is well known that many thousand times the dose is required for alimentary as suffices for respiratory infections.

5. *General Conclusions.*—The evidence collected in the foregoing paragraphs must go far to convince us of the following points: (1) That infection with the tubercle bacillus cannot be avoided in civilized communities; (2) that such infection protects against further tuberculous invasion; (3) that its absence is a danger to the individual; and, furthermore, (4) that alimentary infection with the bovine bacillus will suffice for such immunity, and is comparatively safe contrasted with the great danger of the bacillus derived from human sources. It only remains to draw the inevitable conclusions to which these facts lead. Since infection is practically unavoidable, it is only left to us to decide whether we will voluntarily present to our children the comparatively innocuous bovine bacillus, or leave them to risk a first encounter with the infinitely more dangerous bacillus of human strain. Surely, when the issues are fully seen, even the flabbiest public opinion will accept the former as the only reasonable solution to a difficult problem. How it is to be done is a matter of some moment, for the feeding of a definite number of millions of living bovine bacilli to an infant would painfully shock the feelings of persons who would tolerate equal or more dangerous doses given in the guise of raw cow's milk. The safest and most practical method open to us at the present time seems to me to lie in the use of a well-mixed milk such as the large London dairy companies supply. In such a milk the bacilli will be well diluted, and the danger of massive dosage reduced to a negligible figure. It must not be forgotten, however, that dosage is relative, and the resistance to tubercle is at a minimum during the first few months of life. It would seem best, therefore, to sterilize the milk at first, and gradually add to it increasing quantities of raw milk till this alone is given. Where, as in country districts, exposure to danger from human sources can be avoided, the administration of raw milk might be postponed to a later age with advantage. Complete extermination of bovine tuberculosis is not to be wished for so long as the human tubercle bacillus is rife among us, and fortunately it is but little likely of accomplishment. Our goal should be a clean milk-supply and adequate inspection of small byres and single cows; through these measures danger of massive bovine infection may be eliminated, and the use of raw milk be more safely and confidently recommended.