principal form of adult tuberculosis, is due to the fact that phthisis is usually caused by human bacilli which have been inhaled.

Assuming that bovine bacilli can become transformed into human bacilli in the human body one would expect, unless the change is abrupt and complete, to meet with intermediate forms. Now it has been found that strains of tubercle bacilli of human origin do not always correspond exactly either to the human or to the bovine type, though clearly belonging to the mammalian group. These atypical strains have been considered by those who uphold the doctrine of the convertibility of tubercle bacilli to be intermediate—that is to say, in a transitional stage between bovine and human. For the reasons which I have stated elsewhere this view is probably incorrect. They represent, in my opinion, merely temporary or quasi-permanent variants of one or other of the two forms; they retain characteristics of the types from which they have been derived, and are often capable of complete reversion to the original type.

While there is no certain evidence that bovine bacilli change into human bacilli during residence in human tissues, there is, on the other hand, plenty of evidence that these bacilli can retain their characteristic properties during the whole course of a case of tuberculosis. For example, bovine strains, typical in every respect or only slightly below the normal virulence, have been obtained from seventeen cases of lupus which had lasted from thirteen to fifty-two years (average twenty-two years) and from many cases of phthisis in the adult which dated back to childhood. It is just in the latter form of the disease that one would expect the conditions to be most favourable for mutation. There is therefore no direct evidence to support the view that bovine tuberculosis is responsible for more cases of human tuberculosis than can be ascertained by the ordinary bacteriological methods.

The position disclosed by the facts which I have presented is sufficiently serious—without exaggeration—to demand the greatest efforts to prevent the grave loss through death and disease from this cause, and to bring about the eventual extinction of bovine tuberculosis, not only for economic and agricultural reasons, but also in the interests of human health.

THE ROLE PLAYED BY BOVINE TUBERCLE BACILLI IN HUMAN TUBERCULOSIS*

BY

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At the Congress on Tuberculosis in London in 1901, Koch, as a result of experiments conducted by him, together with Schütz, on cows, asserted that bovine tubercle bacilli were of virtually no importance for human beings. He abandoned this extreme standpoint later, but, in Washington in 1908, he still declared that, while he regarded it as necessary to combat bovine tuberculosis for sound agricultural and economic reasons, he did not desire to see this done in connexion with the battle against human tuberculosis without further grounds. As a result of Koch's initiative, and doubtless also because of the opposition which his point of view evoked among many physicians and investigators, studies of the types of tubercle bacilli occurring in man and animals have been carried on in all parts of the world. Among such studies special importance must be ascribed to those carried on by the British

Royal Commission, by the Reichsgesundheitsamt, and by Park and Krumwiede. I should like to mention also that Robert Koch himself evinced very great interest in the reports of the British investigators. Neufeld tells us that the Royal Commission's report lay open on Koch's desk when he left his institute for the last time. To-day, when the result of the many investigations to which I have referred is available, we can form a fairly dependable conclusion concerning the very practical problem of the importance of bovine tuberculosis for human beings.

THE BOVINE BACILLUS

First of all, it is to be emphasized that it has been possible since Koch's day to confirm thoroughly his opinion that bovine tubercle bacilli can be definitely distinguished from human bacilli by laboratory investigation, and that the characteristics of the types are essentially constant. This fact is of the greatest importance, since it gives us a sure basis for determining the danger which menaces human beings from bovine tubercle bacilli. If the view, still held by some writers, were correct, that the characteristics of type are not constant, and that the one type can metamorphose itself into the other, and, in particular, that bovine bacilli can change into human bacilli in the human body, we should be obliged at the very outset to abandon the attempt to form any judgement as to this source of danger, and to leave the question open as to whether, following the Behring theory, human phthisis pulmonalis is due in the last analysis to the drinking of milk infected with tubercle bacilli in the first few years of life.

In diagnosing types in the Robert Koch Institute we proceed to-day in the following manner:

We secure pure cultures from tuberculous specimens, so far as possible, by the direct method—using the antiformin process or the Loewenstein-Hohn method—and also at the same time by the inoculation of guinea-pigs. As medium for the first culture we employ the egg culture without glycerin, described by Dorset, and alongside it Lubenau's culture with an addition of serum. From the pure culture secured directly by the first method or by the inoculation of guinea-pigs we inoculate the so-called differential culture mediums—bovine serum with and without glycerin, glycerin-agar, glycerin broth. If the result is such a development of the strain as has been shown by the investigations of the Reichsgesundheitsamt and the British Royal Commission to be characteristic for the bovine type, the pathogenicity of the strain is tested on rabbits. We prefer here, following Oehlecker, intravenous inoculation with 1/100 mg. of glycerin broth culture, with which results are achieved more quickly than by subcutaneous inoculation. Along with this we employ a test worked out by Toda in my laboratory, in which three strains to be tested are compared with a bovine strain of known high virulence through intracutaneous inoculation of 1/100,000 mg. in all four legs of the same rabbit. Bovine strains of typical virulence give rise to especially great primary infections of the skin, and above all a caseous tuberculosis of the regional lymphatic glands. Human strains never do this. Through the above method one arrives quickly—at most in two months—at a definite conclusion.

The diagnosis of the type is always difficult if one has to do with bovine bacilli of greatly weakened virulence, such as not infrequently occurs in cases of so-called external tuberculosis of human beings, especially in lupus. But it has been possible for me, with only very rare exceptions, to reach a definite decision as to the type. I share the opinion of Stanley Griffith and Neufeld that intermediate forms between the two types do not exist, but rather that the tubercle bacilli strains described by Lydia Rabinowitsch and other authors as intermediate forms are merely variants of the one or other type, or else mixed cultures of both types.

After these preliminary remarks concerning the method of diagnosing types, I will now endeavour, basing on all

* Read in opening a discussion in the Section of Tuberculosis at the Centenary Meeting of the British Medical Association, London, 1932.

Frequency of Bovine Tubercle Bacilli in Human Tuberculosis in Germany, Compared with Percentages from Other Countries*

Forms of Tuberculosis	Total Number of Cases	Below 5 Years		From 5 to 16 Years		Over 16 Years		No Age Given		Total Number of Cases		†Percentage Bovine	England	Scotland	All Other Foreign Countries
		Human	Bovine	Human	Bovine	Human	Bovine	Human	Bovine	Human	Bovine				
1. Generalized, and meningitis tuberculosa	201	136	10 (+ 2)	23	5	22	0	3	0	184	15 (+ 2)	8.4	30.1	13.3	11.9
2. Bone and joint ...	87	20	0	30	3	32	1	1	0	83	4	4.6	18.0	42.8	1.6
3. Cervical glands† ...	94	15	10	24	10	34	1	—	—	73	21	22.3	45.7	73.6	25.6
4A. Abdominal ...	116	28	14	8 (+ 1)	11	32 (+ 1)	11	10	—	78 (+ 2)	36	32.7	—	—	35.9
4B. Necropsies. Portal of entry: alimentary tract (English authors)	—	—	—	—	—	—	—	—	—	—	—	—	84.6	—	—
5. Genito-urinary ...	24	—	—	1	0	23	0	—	—	24	0	0	17.4	9.1	5.2
6. Lupus ...	160	17	3	36	13	61 (+ 2)	13	12	3	126 (+ 2)	32	21.3	48.6	53.8	9.0
7. Pulmonary and bronchial glands	345	44	2	6	0	281 (+ 2)	0	10	0	341 (+ 2)	2	1.2	0.8	3.8	0.2
8. Phthisis of adults (included in No. 7)	283	—	—	—	—	281 (+ 2)	0	—	—	281 (+ 2)	0	0.7	—	—	—
9. Phthisis of adults probably exposed by their profession to infection by tuberculous cows (milkers, etc.)‡	40	—	—	—	—	—	—	—	—	32	8	23.0	—	—	—

* So-called atypical strains are not considered.

† Mixed infections with both types are counted as bovine.

(The figures in parentheses denote mixed infections with both types.)

‡ A few cases of axillary gland tuberculosis are included in this category.

§ Latest investigations of the Robert Koch Institute.

available experience in this field, to characterize the danger that menaces human beings from bacilli-excreting cattle.

ITS OCCURRENCE IN MAN

In discussing the statistics that give us an idea of the frequency of bovine infection in man, I lay chief weight on the results of the investigations conducted in Germany. I shall refer only briefly to the results in other countries.

A comparison made of the frequency of bovine infection in Germany with its frequency in Great Britain, dealt with by Stanley Griffith, is especially instructive. The above table gives a general survey of the findings.

In Germany there were found: 8.4 per cent. of bovine infections in 201 cases of generalized tuberculosis and tuberculous meningitis, 4.6 per cent. in 87 cases of tuberculosis of the bones and joints, 22.3 per cent. in 94 cases of tuberculosis of the lymphatic cervical glands, 35.8 per cent. in 106 cases of abdominal tuberculosis, no bovine infection in 24 cases of genito-urinary tuberculosis, and 21.3 per cent. in 160 cases of lupus. In 345 cases of tuberculosis of the lungs and bronchial glands somewhat more than 1 per cent. of bovine bacilli were found. Of these 345 cases, 281 were pulmonary tuberculosis of adults, and in only two of these could bovine bacilli be found, and in both cases they were in company with human bacilli—that is, only 0.7 per cent. in all.

I have made a separate category of forty cases of pulmonary tuberculosis investigated in my laboratory in the last few years, all of them patients whose occupations—milkers, stable-boys, etc.—had exposed them shortly before they became ill to infection from tuberculous cows. In eight of these cases bovine bacilli were found in the sputum—that is, in the strikingly high percentage of 20. This number does not include one case of pulmonary tuberculosis in which both human and bovine bacilli were found in the sputum.

INTERPRETATION OF STATISTICS

While the figures of non-German authors in general approximate to those given for Germany, the percentages reported for England and Scotland are considerably higher, those for Scotland mainly higher than those for England.

It is difficult to calculate the frequency of bovine tuberculosis in man from the figures reported, since a frequency of the different forms of the disease which is not definitely known to us must lie at the basis of any such calculation. It is to be borne in mind, for instance, that in Germany, and doubtless in other civilized countries,

some five to six times as many persons die of pulmonary tuberculosis as of all other forms of tuberculosis combined. It must further be borne in mind that not a few of the cases considered were chosen for investigation because there was a clinical suspicion of infection with bovine tubercle bacilli. If we confine ourselves to the lessons taught with certainty by the figures reported, we find the following:

1. Bovine tubercle bacilli were found to be the cause of tuberculosis of man in its most varying forms.

2. The menace of bovine infection is much greater in children than in adults, especially in regard to adult pulmonary tuberculosis.

3. The distribution of bovine infection differs in no slight degree in different countries.

The fact that bovine infection is much more frequent in children than in adults can easily be explained if we consider that milk, the most important source of infection, is one of the chief foods of the child—a circumstance that no longer applies to the adult. What happens when adults—as, for example, in the course of their daily work—are exposed to infection by tuberculous cattle, and especially during the critical period between the ages of 15 and 20, is clearly shown by the findings of the Robert Koch Institute in recent years in the case of forty milkers, stable-boys, etc. Here a percentage was established for bovine tuberculosis which comes precariously close to that of intestinal infection of children in Germany.

The assumption that bovine infection even distantly approximates infection with human bacilli in frequency can be dismissed from the start, even for a country in which tuberculosis of cattle is very prevalent and the necessary safeguarding measures have not been taken; for, in the first place, man is exposed to infection by human bacilli during the whole course of his life, whereas the period of exposure to bovine infection is limited in the main to the first years of life; and secondly, numerous experiments, as well as observations in humans, have shown us that infection through the alimentary tract—as is the case with bovine tuberculosis—is set up with much greater difficulty than infection through the respiratory tract, which is almost without exception due to human bacilli. In this connexion, however, it must be taken into consideration that cow's milk containing bacilli as a rule transmits a greater number of tubercle bacilli, whereas the number of bacilli that reach the lungs through inhalation is always small.

The striking difference in the frequency of bovine infection as found in different countries can be explained by the varying extent of distribution of bovine tuberculosis and by the degree of hygiene maintained in the milk supply of the population.

ITS RELATIVE DANGER

If what has so far been said points to a much more frequent infection with human than with bovine bacilli in man, it would nevertheless be wrong to assume that an infection with bovine tubercle bacilli is less harmful than an infection with human bacilli, as a great number of investigators and physicians, following Robert Koch, still believe to-day. On the contrary, I am of the opinion that the sum of the observations bearing on this problem furnishes no proof whatever for such an assumption. As late as 1908 Robert Koch, speaking before the Tuberculosis Conference in Washington, cited as proof of the lower virulence of bovine tubercle bacilli the fact that up to then the presence of bovine bacilli in the sputum had not been established with certainty in a single case of pulmonary tuberculosis. This argument has been definitely refuted by the most recent observations of W. T. Munro, A. Stanley Griffith, and myself. A further circumstance disproving a lower pathogenicity of the bovine bacilli for mankind is the lack of any noticeable difference in the course of the infection resulting from the type of the bacillus. The course of an intestinal tuberculosis or a phthisis caused by bovine bacilli, to mention an example, is not less severe than that of the same diseases when caused by human bacilli. If it is open, a "bovine phthisis" in man has about the same mortality as the disease caused by human bacilli. Neither can the fact that bovine tubercle bacilli of reduced virulence have frequently been found serve as proof for the assumption that the bovine bacilli have a lower pathogenicity, as, on the other hand, human bacilli of reduced virulence are also found on occasions—in the case of lupus quite as frequently, in fact, as are the bovine. Other arguments that have been cited as proof of the lower pathogenicity of the bovine bacilli for mankind have quite as little foundation in fact, as I have pointed out on former occasions.

Although we must therefore agree with Robert Koch in his demand that the battle against tuberculosis be concentrated primarily against infection from man to man, in view of the much lower frequency of bovine infection as compared with that of human, it is my conviction that the widespread opinion still existing to-day that infection with bovine bacilli is comparatively harmless for mankind must be rejected as having no foundation in fact. I am in this respect in perfect accordance with A. Stanley Griffith, who has been stressing this view repeatedly for many years.

Taking into consideration all the known facts concerning bovine infection, we have every reason to employ all the means at our command to combat this source of tuberculosis in man. We are all the more bound to such a procedure by the fact that we are able to institute much more effective measures against the transmission of bovine tubercle bacilli to human beings than are at our disposal for the prevention of tuberculous infection from man to man.

The view held by some physicians to the effect that a light bovine infection acquired in childhood might even be useful to a certain degree as a means of developing immunity against later infections, represents, in my opinion, a dangerous argument. Quite apart from the fact that the protection resulting from an infection is thoroughly problematic, the additional fact that no one can predict just what may develop in later years out of even a slight infection with bovine bacilli should prevent

anyone from drawing conclusions on the strength of this hypothesis affecting our actions in practice.

PREVENTIVE MEASURES IN GERMANY

In what follows I wish to call attention to the methods used in Germany against bovine infection in man.*

Percentage of Cattle Affected

In regard to the extent of bovine tuberculosis in Germany, the rate of distribution varies greatly in the different parts of the country. In some districts in Germany we find only a low percentage of open tuberculous animals, even as little as 0.5 per cent.; in other districts, however, it is as much as 10 and 20 per cent. By far the greater part of the tuberculous infections are open cases of pulmonary tuberculosis, aggregating even more than 90 per cent. The proportion of udder tuberculosis is very small, as it amounts to only about one-thirtieth of the cases of pulmonary tuberculosis. Comparatively speaking, a still smaller part is played among the total number of infections by tuberculosis of the womb and intestinal tract. The combat against bovine tuberculosis in Germany is carried on partly through legislation and partly through voluntary measures under State supervision.

The Extermination Method

We have the "Viehseuchengesetz" (animal contagious disease law), which came into effect in 1912. Under it the owner of animals is under obligation to report any externally recognizable tuberculosis occurring among his stock. Of much greater importance in practice is the "Tuberkulose-Tilgungsverfahren" (method for exterminating tuberculosis), which has been in existence for about thirty years. The farmers and agricultural associations voluntarily participating in the exterminating method must submit to the following regulations:

1. Their herds must undergo a clinical examination at least once a year by a veterinary surgeon chosen by the authorities. Badly infected stock must, in the interests of the owner, be examined twice a year if possible. In addition, a bacteriological examination for tubercle bacilli must be made at least three times a year of a test taken from the combined milk yield of all the cows in the herd.
2. The owner is bound immediately to follow the directions of the examining veterinary surgeon concerning the isolation and other methods of treatment of any animals that appear suspect.
3. The calves must be separated from their mothers when they are two days old, and must be fed either with boiled milk or with raw milk from medically tested selected cows.
4. The costs of this procedure are borne in part by the State and in part by an assessment of the owners of the stock. The owners are recompensed for animals killed by order of the veterinary surgeon, one-third of the payment coming from the State and two-thirds from the provinces, out of the dues paid by the owners of the stock.

The Results

More and more agricultural enterprises are participating in the "method for exterminating tuberculosis" every year. In Prussia about 20 per cent.—that is to say, a little more than 2,300,000 of the total number of cattle—are at present included in this procedure. These 20 per cent. include the most severely contaminated herds and most of the large dairies and breeding associations of importance for the general milk supply, so that practically

* The following information was furnished by Dr. Scharr, director of the Bacteriological Institute of the Chamber of Agriculture for the Province of Brandenburg, and by Dr. Wiemann, Councillor in the Ministry for Agriculture.

50 per cent. of the total danger sources are thus under observation. It may be of interest to state that in the year 1930 a total of 81,000 animals were reported ill and suspect, 43,880 head of cattle were killed in Prussia as a result of this method, and over nine million marks were paid the owners of the slaughtered animals in the same year as compensation. The owners of herds are in ever greater degree learning to appreciate the economic advantage resulting from the elimination of all tuberculous cattle. This growing interest, coupled with propaganda stressing the value of sending the cattle to pasture as compared with the unhealthy process of keeping them stabled, is resulting in a steady increase in stock free from tuberculosis.

Milk Inspection

Mention should be made of still another extremely important measure against the infecting of man with bovine tubercle bacilli—namely, the official inspection of the milk, and the process of pasteurizing and other methods of applying heat in order to destroy any disease germs contained therein. The new "Reichsmilchgesetz" (national milk law) of 1930 contains drastic provisions concerning the inspection of stock, the methods of milk production, and the sale of milk. An especially important provision of the milk law for decreasing the menace of infection is that every cow furnishing milk to be sold as of certified high quality must come under the scope of the "tuberculosis exterminating method," and that it is also prohibited to use the milk for human consumption, even when boiled, of cows suffering from any form of open tuberculosis or even highly suspect. Another factor in the prevention of infection with bovine tubercle bacilli is the practice, quite common in Germany, of regularly boiling milk for private consumption, especially in the case of milk intended for children.

It is to be hoped that the measures here described will bring about in the not too distant future a reduction to a minimum of the danger that menaces mankind from tuberculous cattle.

IMPORTANCE OF RESEARCH

In conclusion, I should like to point out that the researches being carried on in Germany and other countries into human tuberculosis caused by bovine bacilli are important, not merely as a criterion for the dangers of the bovine bacillus for man, but also as a means of shedding light on many other important tuberculosis problems. This is especially so of the most recent observations on bovine bacilli in the sputum of human adults. Whereas according to the case history at least one-half of the cases of phthisis reported by Munro and Griffith must have developed from an infection acquired many years earlier, in childhood, the cases of pulmonary tuberculosis examined bacteriologically by me are probably all due to an infection acquired in adult years. There is no other explanation for the fact that of my cases of phthisis which were proved or suspected to have been exposed to bovine infection as adults, 20 per cent. were infected with bovine bacilli, whereas in the sputum of 281 other phthisis patients formerly examined in Germany, bovine bacilli were found to be the cause of the infection in only two cases—that is, 0.7 per cent.—and even in these two cases human bacilli were also present. Naturally our figures are as yet too scanty to permit us to form a definite opinion. I am convinced, however, that a systematic continuation of such research work into "bovine phthisis" will furnish us with valuable information concerning a problem which is to-day again claiming general interest—I refer to the question of the importance of childhood infection on the one hand, and of adult infection on the other, in human pulmonary tuberculosis.

THE END-RESULTS OF THE TONSIL AND ADENOID OPERATION IN CHILDHOOD AND ADOLESCENCE*

BY

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AND

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We have been asked to deal with this subject particularly from the statistical point of view. First, let us define two things:

1. For brevity, the single word "tonsillectomy" will be used throughout this paper to mean the double operation for the removal of tonsils and adenoids.

2. "End-result" means anything which may result *after convalescence* from the operation is *complete*; therefore all the more immediate risks of the operation are excluded from this paper.

The assessment has been attempted by many authorities, but in view of the vast number of tonsillectomies now performed, it would seem that no more important or urgent subject for a centenary discussion in this Section could have been chosen.

Increased Use of Tonsillectomy

Table I and Diagram 1 show the number of elementary school children officially recorded by the education authorities as operated upon in England and Wales and in London for a number of years. While in London the

TABLE I.—Number of Tonsillectomies Officially Recorded Annually in Public Elementary School Children for London and England and Wales Respectively.

	London	England and Wales
1923	7,656	47,685
1924	8,051	49,436
1925	12,179	60,871
1926	13,165	68,250
1927	14,843	80,548
1928	17,372	92,171
1929	17,186	97,518
1930	18,119	109,738
1931	18,178	—

DIAGRAM 1.—Number of tonsillectomies performed on elementary school children in England and Wales annually, 1923 to 1930. (Board of Education: Annual Reports of the Chief Medical Officer.)

curve shows some evidence of becoming stabilized, the increase in England and Wales is still rapid. This rapid increase (to two and one-third times as many in 1930 as in 1923) has occurred in spite of repeated warnings from the

* Read in opening a discussion in the Section of Oto-Laryngology at the Centenary Meeting of the British Medical Association in London, 1932.