THE INFLUENCE OF DUST INHALATION UPON THE INCIDENCE OF PHTHISIS.*

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Predisposition is to-day the key note to the tuberculosis problem. Eradication of the infecting agent, the tubercle bacillus, is not a practical proposition in the same way that the infective agent of yellow fever or of malaria may be eradicated by destruction of mosquitoes, that of typhus by war upon the body louse, or that of enteric fever by ensuring a pure water supply. Further, even if eradication could be ensured, the question would arise as to how great the final benefit to the community would be, since tuberculosis is for the most part an index disease, that is it is closely correlated with the death-rate from all other causes, and its prevalence is a direct indication of the prevalence of sub-normal health in the community. Greater benefit must follow from increasing the resisting power of the nation, so that not only tuberculosis but other forms of disease as well, are held at arm's length. There is definite evidence that just as typhus has gone from this country and typhoid is rapidly disappearing, so, although we are uncertain as to the reason, phthisis also is diminishing, while simultaneously the general death-rate has been falling.

TABLE I.
COMPARATIVE MORTALITY OF ENGLAND AND
WALES SINCE 1851.

Period.	MALES.			FEMALES.		
	Phthisis. All Causes.			Phthisis. All Causes.		
1851-60 ..	100	..	100	106	..	91
1861-70 ..	97	..	102	96	..	91
1871-80 ..	88	..	99	79	..	85
1881-90 ..	73	..	90	62	..	78
1891-1900 ..	61	..	88	46	..	75
1901-10 ..	50	..	75	35	..	62
Fall in 50 years	50%	..	25%	67%	..	32%

N.B.—The death rates are expressed as percentages of the male rate for 1851-60 which was for All Causes 22·1 per 1,000, and for Phthisis 2·6 per 1,000.

The figures given in the table show how phthisis continues to be a pointer to influences which lower resistance to disease. Among these influences the condition of the atmosphere stands probably first. That it does influence general health is indicated by analysis of mortality data

such as that made by Brend (1), who concluded that excess of infantile mortality is due to some factor or factors in industrial towns, the centres of large cities, and mining areas, of which possibly the most important is the polluted state of the atmosphere. Similar conclusions as to the influence of atmospheric conditions follow from analysis of adult mortality data. But the influence of the atmosphere on general health, and particularly on the incidence of tuberculosis, is a large subject upon which I am not embarking. My intention is only to refer to the influence of dust particles which may be inhaled.

Some apology might be needed from me in venturing to deal again with this aspect of tuberculosis. But there seems to be still some lack of appreciation as to where we stand to-day in relation to the matter, and also there is some new evidence to report. Hence I venture to return again to the subject.

Particulate matter which may be inhaled is as various in its composition as that of matter in general. It may be composed of (a) viable cells, *i.e.*, micro-organisms; (b) dead animal or vegetable substances, or (c) inorganic material. Each group, from the point of view of inhalation, is important.

Viable Particles.—The only member of this group is the tubercle bacillus itself. Some authorities, I am aware, favour the intestinal tract as the main portal of entry, and hold that pulmonary tuberculosis results from alimentary infection which may have taken place years before. I may personally be prejudiced against this view since I recall (1) how industrial lead poisoning used to be ascribed in the main to material which was swallowed, until Goadby showed that poisoning followed upon inhalation of one hundredth part of the dose necessary if administered by mouth; and (2) how Calmette at one time claimed that dust found in the lungs did not get there through direct inhalation, but only *via* the digestive tract.

Certainly there stands the undoubted fact that animals can be infected aurally. Until proof to the contrary is forthcoming I incline to the view that adult phthisis as seen in industries is a new infection, probably air borne. For the moment I am content to lay stress on the fact that, other things being equal, phthisis among adults is more prevalent in crowded communities, where exposure to direct infection is more possible. The theory of adult infection may be held to receive support

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from the unusual mortality from phthisis experienced in sedentary or semi-sedentary occupations, such as shoe-making, printing, and tailoring, wherein aggregation of individuals seems to be one factor distinguishing the conditions from those of other occupations.

A number of other possible factors have been considered (2):—fatigue, hereditary predisposition, poverty and consequent malnutrition, alcoholism, housing, infection from materials used, legal overcrowding, cramped position at work, and sedentary character of work; only to be rejected when these industries are compared with other occupations with lower mortality from phthisis. Thus to take two only:—the claim that phthisis is here a *pestis pauperum* fails, for the shoemaker certainly receives no less a wage than operatives employed in the manufacture of hosiery. While the physical attributes of the atmosphere are not more unfavourable than in textile industries where the incidence of phthisis is not abnormal, but where individuals are further separated. In the three industries named in the preceding paragraph phthisis is the only great cause of death markedly in excess, so that difficulty arises in accepting the view that the excess is due to general lowering of resistance to disease. When general resistance is lowered, as by alcohol, every cause of death should, on theory, be found in excess, and indeed this is found to occur among innkeepers and publicans. (See Table 2). When general resistance is increased as by outdoor life, every cause of death should be found diminished, and this is found to occur among agricultural labourers.

TABLE II.
COMPARATIVE MORTALITY IN CERTAIN
OCCUPATIONS, 1900-02.*

Class	Phthisis	Nervous	Diseases of the Circulatory Systems.	Respiratory	All Causes.
ALL MALES ..	186	105	144	174	1,000
Labourer in Agricultural Districts ..	75	52	102	80	567
Coal Miner (Lancashire)	98	77	121	261	939
Wool, Worsted operative ..	161	92	150	155	917
Hosiery oper- ative ..	200	93	129	142	862
Cotton opera- tive ..	214	100	140	199	1,010
Innkeeper, Publican ..	232	175	209	250	1,709
Tailor ..	243	89	123	145	950
Shoemaker ..	247	83	136	140	916
Potter ..	291	98	199	425	1,372
Printer ..	323	71	107	110	903
Cutler ..	506	105	206	300	1,468
Tin Miner ..	851	77	161	735	2,160

* Figures above the standard set by All Males are printed in heavy type.

When local resistance is lowered as in the case of the cotton operative by cotton dust, of the cutler, potter and tin miner by silica dust, and of the coal miner by rock dust, the effect is to increase the incidence of diseases which attack the locality concerned, in this case the respiratory organs. (3) But if we postulate merely increased exposure to a definite infection, the only result to be anticipated is increase of the disease caused by the infecting organism; and the mortality data of shoemakers, printers and tailors appear to present instances where this exposure to an undue amount of infection with tubercle bacilli exists.

I have previously referred (4) and shall refer again later to this method of statistical differential diagnosis; for the moment I ask for consideration of the evidence it appears to give in support of direct personal infection with tubercle bacilli, probably air borne.

Dead Animal and Vegetable Substances.—

This group is promising to be one of great interest. Evidence is gradually accumulating to show that so far as phthisis is concerned, dusts belonging to this group fall into two classes, one including dusts which are innocuous, and the other including dusts which may be positively beneficial.

As long ago as 1913 when dealing (5) with the effect of dusts in producing diseases of the lungs, I suggested that dusts appear to be more injurious as their chemical composition differs from that of the human body, or from the elements of which the body is composed. The chemical composition of this group of dusts is closely allied to that of the body. And the evidence before us is that no class of persons exposed to the inhalation of this group of dusts is known which experiences a high incidence of phthisis, unless that incidence can reasonably be ascribed to other influences.

The possibility of dusts belonging to this group acting as carriers of tubercle bacilli cannot be neglected when considering either this group or indeed any other group of dusts. Theoretically any form of dust may thus assist in the dissemination of tubercle; but I know of no definite evidence bearing on the question. Consideration of this carrier possibility belongs rather to the question as to whether pulmonary tuberculosis arises from aerial infection. If we accept this possibility then we may reasonably accept that infected dust particles, as well as isolated bacilli, may give rise to infection.

The evidence that some organic dusts may be beneficial rests on the prevalence of phthisis in two industries (i.) coal-mining, and (ii.) the manufacture of ganister bricks.

Coal-mining.—The low death rates from phthisis experienced by coal miners on every coal-field (*see Table 3*), not only in this country, but also abroad, compel us to admit that coal dust exerts a definite inhibitory influence upon the prevalence of phthisis. I shall consider later variations in phthisis mortality which occur on the different fields. For the moment I wish to point to the fact that coal dust appears to exert a favourable influence. So much is this accepted that the proposal has been made to dust the galleries of gold-mines with coal dust to prevent miner's silicosis.

TABLE III.

MORTALITY FROM PHTHISIS AMONG COAL MINERS.

Coal-field.	Total No. of deaths.	Comparative mortality figure.	Median age at death.
1900-02.			
Nottinghamshire and Derbyshire	160	.. 64	.. 34
Staffordshire	119	.. 66	.. 35
Durham and Northumberland.. ..	450	.. 84	.. 31 to 32
Yorkshire.. ..	255	.. 88	.. 37 to 38
Monmouthshire and South Wales	434	.. 93	.. 34 to 35
Lancashire	269	.. 96	.. 38
Occupied and Retired Males	64,097	.. 187	.. 38 to 39
1910-12.			
Nottinghamshire	79	.. 53	.. 29 to 30
Derbyshire	144	.. 70	.. 34
Durham and Northumberland.. ..	541	.. 70	.. 31 to 32
Monmouthshire and South Wales	476	.. 70	.. 37
Staffordshire	155	.. 74	.. 34 to 35
Yorkshire.. ..	404	.. 81	.. 36 to 37
Lancashire	365	.. 107	.. 40
Occupied and Retired Males	58,492	.. 142	.. 38 to 39

While the possibility of coal dust exerting a favourable influence requires to be carefully looked into, sight must not be lost of the way in which miners work. Both underground and on the surface they work far apart; there is but little personal contact, but little possibility of passing on infection.

Recent investigation in the iron and steel industry (6) has brought to light a similarly low phthisis mortality among furnace men which is associated with an abnormally high mortality from

respiratory diseases, ascribed in this instance to exposure to climatic conditions. These men also work far apart.

This view of the case would place adult phthisis alongside whooping cough, measles, and scarlet fever among the diseases directly communicable from person to person.

TABLE IV.

MORTALITY FROM PNEUMONIA AMONG COAL MINERS.

Coal field.	Total No. of deaths.	Comparative mortality figure.	Median age at death.
1901-02.			
Nottinghamshire and Derbyshire	114	.. 52	.. 46 to 47
Durham and Northumberland.. ..	228	.. 54	.. 49 to 50
Yorkshire	195	.. 71	.. 44 to 45
Staffordshire	117	.. 71	.. 51
Monmouthshire and South Wales	456	.. 108	.. 42 to 43
Lancashire	370	.. 149	.. 43 to 44
Occupied and Retired Males	35,517	.. 92	.. 49 to 50
1910-12.			
Derbyshire	77	.. 34	.. 49 to 50
Nottinghamshire	67	.. 40	.. 47 to 48
Durham and Northumberland.. ..	379	.. 54	.. 51
Yorkshire.. ..	317	.. 69	.. 48 to 49
Monmouthshire and South Wales	457	.. 69	.. 45 to 46
Staffordshire	137	.. 70	.. 48 to 49
Lancashire	366	.. 100	.. 48
Occupied and Retired Males	32,628	.. 67	.. 51 to 52

Ganister Bricks.—Ganister is a quartzite rock, *i.e.*, it is a form of pure silica, and those who inhale ganister dust suffer from an excessive mortality from tubercular silicosis; but if this stone is mixed with fireclay as it is in making second grade bricks, the dust loses its pernicious character (*See Table 6*). All clays do not have this effect, only fireclays; certainly pottery clay does not render flint dust harmless to potters.

Fireclays are grouped here because their influence probably depends on their containing certain organic constituents. This matter will be referred to again later.

Two little is known to-day of the possibility of other dusts in this group, exerting a favourable influence. The subject is worth close attention. Ten years ago all forms of dust were condemned as dangerous. Then attention was drawn by me to the particularly pernicious nature of silica dust, and to the fact that so far as phthisis is concerned, no other dust appeared to be similarly injurious.

A further advance is now being made through recognising that some dusts of organic origin may have a favourable influence.

INORGANIC DUST.

This group also has two sub-divisions: (i.) inert dusts, (ii.) injurious dusts.

Inert Dusts.—The majority of inorganic dusts, although most of them undoubtedly predispose to such respiratory diseases as asthma, pneumonia and bronchitis, are inert so far as phthisis is concerned. Dusts of limestone, oxide of iron, plaster of Paris, alabaster, and plastic clays are examples of inorganic dusts which appear to exercise no influence upon any form of pulmonary disease.

Basic slag, emery and glass are examples of inorganic dusts which predispose to pneumonia and bronchitis, but not to phthisis.

Harmful Dusts.—This group, so far as evidence goes to-day, is entirely made up of the various forms of silica dust. We do not know of the occurrence of that form of fibrosis which predisposes to tuberculosis, resulting from dust inhalation, among any group of persons except those exposed to the inhalation of silica dust (8). The silica must be free in the form of flint, quartz, or quartzite, and not in the form of a salt, *i.e.*, as a silicate. Geologically I should remind you that silica is considered an acid. Chemically, it belongs to the same group as carbon, and it possesses a similar capacity to carbon for forming colloidal compounds.

The case, so far then, is that there are (a) some dusts of organic origin which exert a favourable influence upon the incidence of phthisis, (b) some dusts, mostly inorganic, which are neutral, and (c) others, composed of silica, which are definitely harmful.

The next question is to consider what occurs when harmful and favourable dusts are mixed. I have already alluded to two instances, and must now deal with them in greater detail.

Coal Mining.—Coal miners are exposed not merely to coal dust, but to dust arising from the rocks among which coal is found. These rocks undoubtedly contain much free silica; yet the coal miner does not succumb to tubercular silicosis. Mine dust, nevertheless, does not affect all miners alike. Some men, the colliers, get coal, while others rip away the rock; the latter get more rock dust. On some coal fields, of which Lancashire is an instance, owing to the lie of the coal, more rock ripping is done than on others. On these coal

fields the incidence of phthisis (although absolutely low), when compared with that of other fields, is high (*see Table 3*).

The figures here given also show that on these fields the incidence of pneumonia and bronchitis is much above the normal. (*See Tables 4 and 5*).

TABLE V.
MORTALITY FROM BRONCHITIS AMONG COAL MINERS.

Coal-field.	Total No. of deaths.	Comparative Mortality Figure.	Median age at death.
1900-02			
Durham and Northumberland	256	.. 41	.. 64 to 65
Nottinghamshire and Derbyshire	170	.. 49	.. 67 to 68
Yorkshire	221	.. 67	.. 62 to 63
Staffordshire	252	.. 104	.. 64 to 65
Monmouthshire and South Wales	435	.. 104	.. 61 to 62
Lancashire	296	.. 113	.. 58 to 59
Occupied and Retired Males	40,292	.. 58	.. 66 to 67
1910-12.			
Nottinghamshire	87	.. 25	.. 71
Durham and Northumberland	414	.. 33	.. 67 to 68
Derbyshire	144	.. 39	.. 67 to 68
Yorkshire	330	.. 45	.. 66 to 67
Staffordshire	244	.. 61	.. 67 to 68
Monmouthshire and South Wales	538	.. 66	.. 64 to 65
Lancashire	462	.. 88	.. 64 to 65
Occupied and Retired Males	37,648	.. 38	.. 67 to 68

There is a further point:—the data presented indicate that the less the amount of phthisis, the younger are its victims. This varying median age at death has its importance in view of Dr. John Brownlee's conclusion (9) that there are different types of phthisis, one of which he calls "old age" phthisis. Concerning this type he writes: "The only association which has been made out quite definitely and beyond dispute is that it is especially common among miners, coal, iron, lead, etc., and also among the workers in the Welsh slate quarries. The cause of this association is at present quite unknown." The presence of an undue amount of this type of phthisis in any group of miners would raise the median age at death from phthisis among the group.

Reference has already been made to the importance statistically of the prevalence of other respiratory diseases such as pneumonia and bronchitis, when the relation to phthisis of dust inhalation is under consideration. The incidence

of these diseases among coal miners is important. No suggestion has been put forward that coal dust in any way checks the incidence of these diseases.

Pneumonia among Coal Miners.—The mortality from pneumonia on the different fields is found to vary within wider limits than that of phthisis. Moreover, for certain fields it exceeds the standard given for occupied and retired males. In both decennial periods the same three fields are at the bottom of the list, with Lancashire maintaining its unenviable last place. The miner on the Lancashire field in 1900-02 stood among the twenty-six occupational groups with the highest mortality from pneumonia; a position shared in 1890-02 by the miner of Monmouthshire and South Wales. Derbyshire, Nottinghamshire, Durham and Northumberland are at the top for both decennial periods, and they appeared in 1900-02 among the twenty-seven occupations with the lowest mortality from pneumonia. In the case of this disease (in contradistinction to phthisis) the tendency is for the median age at death to be lower than normal in those fields where the mortality is high. If we accept that the disease is influenced by dust inhalation lowering the pulmonary resistance this tendency is what might be expected.

Bronchitis among Coal Miners.—The mortality from bronchitis on the different fields varies within wider limits than in the case of pneumonia. Here again the standard is sometimes exceeded and to a greater extent and by more fields. The same three fields, found at the bottom for the pneumonia mortality, are again at the bottom for both decennial periods; and again Lancashire is easily last. Nottinghamshire, Derbyshire, Durham and Northumberland, are again found top in both periods. There is the same tendency as in the case of pneumonia for the median age at death to be lower than normal in those fields where the mortality is higher.

The position appears to be as follows :—On some coalfields there is exposure to injurious dust containing silica, which causes bronchitis and pneumonia and would cause an excess of phthisis were it not for the coal-dust; but the effect of silica in causing phthisis is in some way interfered with by coal-dust. On other coalfields where the exposure to silica dust is less, bronchitis and pneumonia are less prevalent, and the favourable influence of coal-dust is more clearly manifested.

Ganister bricks.—This industry (10) is even more interesting. Good ganister contains upwards of 98 per cent. of silica; it is a valuable refractory material, used for the manufacture of bricks, employed for lining steel furnaces. Lime is used to hold the material together in making first grade bricks. The men who make these bricks are exposed to silica dust and suffer a heavy mortality from tubercular silicosis (*see Table 6*).

The data given in Table 6 express this mortality as a percentage, 76 per cent. of deaths from All Causes. In one district, where a mortality per 1,000 living could be roughly calculated for the ganister brick makers, it was found to be somewhere about 37 per 1,000 per annum, as contrasted with 1·3 for the town where they worked, 1·0 for makers of ordinary house bricks and plain tiles, and 2·0 for All Males. In this district the deaths from other respiratory diseases among the silica-brick makers amounted to somewhere about 16 per 1,000 per annum as contrasted with 2·1 for ordinary brick makers and 2·8 for All Males. Probably the percentage of deaths due to other respiratory diseases stated in Table 6 for first grade silica-brick makers underestimates the prevalence of this cause of death, owing to the large percentage of deaths due to phthisis overwhelming the percentages due to other causes.

Poor ganister contains some fireclay in addition to some 87 per cent. of silica; this clay is used to hold the material together for making a second

TABLE VI.
GANISTER-BRICKMAKERS.—DEATHS AT ALL AGES.

Cause of death.	Number.		Per Cent.			Median age at death.		
	Makers of silica bricks.		Makers of silica bricks.		All males.	Makers of silica bricks.		All Males.
	First grade.	Second grade.	First grade.	Second grade.		First grade.	Second grade.	
Phthisis	103	2	76·3	4·6	12·8	39 to 40	...	38-39
Other respiratory diseases	14	12	10·4	27·2	17·8	40	...	60-61
All Causes	135	44	100·0	100·0	100·0	40 to 41	48 to 49	57-58

Constructed from Report on the Manufacture of Silica Bricks. W. S. Smith and E. L. Collis.

quality of bricks. The men who make these bricks, although exposed to dust like the other men, have not been found to suffer from tubercular silicosis. Fireclay, which I would remind you is a coal measure rock found beneath the coal, in some way seems to counteract the influence of silica. The position here seems to be somewhat as follows:—An acid material, silica, when it reaches the lungs in fine particles sets up a reaction which results in the formation of fibrous tissue, now known pathologically as silicosis. Lungs so damaged fall a ready prey to the tubercle bacillus. Silicon like carbon forms colloidal compounds. Silica in fine particles can also do this. But the power of silicon compounds to become colloidal is interfered with by the presence of acids.

Fireclays, which are silicates mixed with some free silica, when first brought to the surface will not work satisfactorily; they are not sufficiently plastic; the custom in the trade is to leave them to “weather” for years, after which they become more plastic, *i.e.*, more colloidal. To-day, “weathering” is thought to consist in the washing away of certain organic acids, which have been carried down into these clays from the overlying coal measures. After “weathering,” fireclay becomes colloidal; and potters’ clay, which is prepared by carefully washing, so that even if it originally held any organic acids, it is freed from them, exerts no inhibitory effect upon the action of free silica.

SPECULATION.

The suggestion may, therefore, be tentatively made that when silica dust is inhaled with raw fireclay dust, the organic acids in the latter prevent the silica particles from becoming colloidal before they are removed by phagocytic action.

The next suggestion is that fine silica dust not so prevented from becoming colloidal, may enter into the colloidal carbon compound, the protoplasmic tissue of the lungs, with the formation of a silica-carbon compound, which we know as silicotic fibrosis; and that this tissue of low metabolic activity, falls an easy prey to tubercle bacilli.

You will recall how, in the first chapter of his text book on Physiological Chemistry, Bunge wrote:—“Silicic acid and carbonic acid are ‘the two great powers in the construction of the earth,’ and are always at war with each other, with alternate victory and defeat on each side.” In the cold and in the presence of water, carbonic acid is in the ascendent; but at higher tempera-

tures silicic acid is the more powerful. This chemical rivalry in the external world surely does not cease within the living body where chemical processes take place at lower temperatures than are needed in the laboratory; theory rather suggests that when silica is introduced into the body some definite chemical reaction should occur. This theoretical reaction may be likened to that proposed by Llewellyn (12) in relation to the formation of gout tophi, which he holds is determined by the precipitation of crystalloids held in concentration at the surface of colloid elements; these elements in their turn acting as determinants of precipitation when crystalloids are in excess. In this instance inorganic biurate of sodium is deposited in an organic framework, but in the case of silicosis the theory postulates the formation of carbon-silicon tissue of low vitality.

I would remind you when venturing on this suggestion that carbon and silicon are both tetravalent elements belonging to the same group; and chemistry teaches that when two such elements are in solution together they always share in the chemical combination present. There is, therefore, no chemical objection to this theory.

Those of you who are acquainted with the interesting work done by Haldane and Mavrogordato will recognise that the theory above outlined, while it is in no way in opposition to the adsorption theory put forward by them, attempts an explanation of the formation of fibrous silicosis.

We have to face in silicosis the formation of tissue as new and as out of place as a gouty tophus. The most recent work on gout, already alluded to, demands the interposition of one or more infective micro-organisms to determine the precipitation of biurate of sodium. Only lately Watkins-Pitchford in South Africa has pointed out that latent silicosis is precipitated by tubercular infection (13).

Personally I have long leaned to the view that the explanation of silicosis will be found to be intrinsically a bio-chemical one. The mechanical explanation that it depends on the sharpness and hardness of the particles does not seem to me to suffice. Particles of emery and of glass are as sharp and as hard as those of silica, yet those exposed to their inhalation while suffering in excess from bronchitis and pneumonia, do not suffer from any pronounced excess of phthisis, nor have their lungs been found to exhibit either the clinical signs of fibrosis or the mottling typical of fibrous silicosis

when submitted to radiography. Further the mechanical explanation loses sight of the minuteness of the particles concerned and their slow rate of movement in the alveolar air which must entirely neutralise any possible abrasive properties. These particles can only be imagined as just floating into the alveoli on deep inspiration, and as being moved from thence either by phagocytosis or by the gentle pressure of respiratory movements.

To-day the theory put forward may be little more than a speculation. Nevertheless it suggests interesting problems for bio-chemical investigation.

Probably the chain which determines tuberculosis, like the chain of other pathological disturbances, has at least three links. The first is the link of latent capacity, inherited predisposition if you will—the capacity living matter possesses of having its normal metabolic changes disturbed—a capacity which varies with races, individuals and occasions. The second link represents the conversion of this latent capacity into a real capacity, whether through trauma or other interferences with normal metabolism. The third represents infection which in the case of tuberculosis is accepted to be a particular bacillus, although, in the case of other disease entities, such as pneumonia, one or more micro-organisms, non-pathogenic possibly in the absence of the second link, may by the precipitating cause.

There is to day but little probability of establishing control of the first link which represents eugenics; or of the third link which would mean eradication of the bacillus. The second link remains, the link of bio-chemistry; here the phenomena associated with silicosis may give help. The first problem is to ascertain what influence fine silica particles alone exert on the tissues; and second to ascertain whether this influence is affected by the presence of fireclay. Then, starting backwards from the last link, to ascertain what influence coal dust exerts on the tubercle bacillus; and what is the relation between fibrous tissue and the tubercle bacillus.

Trauma is accepted to be a starting point for fibrous tissue and for localising tuberculosis, yet the relation of the bacillus to fibrous tissue has not, so far as I am aware, been worked out. Certainly the ash of silicotic fibrous tissue has been found in South Africa to contain a fair amount of phosphorus as well as of silica. The origin of this phosphorus may be nuclein, which contains 7 to

8 per cent. phosphorus, but attention may be drawn to the presence of phosphorus in most specimens of silica. The amount, though not large, has been enough to give rise to poisoning when phosphor-etched hydrogen is evolved from ferro-silicon. These points gain interest from consideration of the chemical composition of the ash of tubercle bacillus which has been stated (14) to be:—

	Per Cent.			
Sodium	13'62	...	9'18	
Potassium	6'35	...	26'55	
Calcium	12'64	...	2'17	
Magnesium	11'55	...	3'22	
Silica	0'57	...	0'19	
Phosphoric acid ...	55.23	...	51.15	
Chlorine	?	...	6'60	
Sulphuric acid ...	?	...	0'84	

I should, however, point out that knowledge concerning the chemical composition of the ash of micro-organisms is not extensive, and considerable search has failed to discover any other analyses for comparison with these for the tubercle bacillus. Even these are too diverse for reliance to be placed on them. Further, I can find no chemical analyses of ordinary fibrous tissue.

The utmost for the moment which can be said is that silicotic fibrous tissue seems to provide the food required by the bacillus.

Even should further investigation show some affinity between the tubercle bacillus and fibrous tissue, still no explanation is afforded of why the coal miner experiences an unusually low mortality from phthisis. Here for the present I am content to recognise the fact and to avoid further speculation.

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RAT REPRESSION IN THE CITY OF MANCHESTER.*

BY

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The reason this subject was selected was that, apart from the stress laid upon this work by the Ministry of Agriculture and the impetus given to it by recent Rat Weeks, it was thought that we should be able to learn from the discussion something of the different methods adopted and of the work done in different localities, and so be of assistance to one another.

Occasional complaints of damage caused by rats have been received and dealt with by the Public Health Department in previous years, but no special effort was made to deal with the rat problem until the responsibility of carrying out the duties of the Rats Order of 1918 was placed on Local Authorities by the further Order known as "The Local Authorities (Food Control) Order (No. 5), 1918."

The administration of the Order in Manchester was at first undertaken by the Local Foodstuffs Committee, who, after making certain investigations as to the nature and extent of rat infestation in the city, passed a resolution on June 25th, 1919, suggesting that the work should be carried out by the Public Health Committee. This was arranged in September, 1919, and the work has since been carried out under the direction of the Medical Officer of Health.

Preparations were made for the National Rat Week, which was held in October, 1919. Handbills, large posters, and press notices were issued, impressing upon owners and occupiers of infested premises the necessity for taking concerted action for the destruction of rats.

Infested premises were visited by Sanitary Inspectors, pamphlets were left dealing with methods of destruction which could be adopted and subsequent visits were paid to ascertain results.

From the information obtained as a result of the above measures, it was evident that certain parts of Manchester were badly infested, and it was decided that for a successful and continued campaign against rats it would be necessary to appoint a whole time Rat Executive Officer.

This Officer was appointed in March, 1920. Rat weeks were held in Manchester in January and March this year.

These rat weeks were a means of stirring up the public to the necessity for concerted action, and the complaints, which came in as a result of the advertisements, afforded useful information as to the parts of the city which were infested.

The type of rat found in the city is the brown rat (*rattus norvegicus*). It is sometimes called the sewer rat, and is found in sewers, drains, basements of buildings, stables, and in burrows on canal and river banks. It is a great burrower, and very often finds entrance to buildings through defects in the drainage system. Certain vacant plots of land adjoining warehouses in the city have been found to harbour many rats; their runs have been traced to defective basement windows, doors and ventilators. The black rat (*rattus rattus*) is found in small numbers in the docks at Manchester and frequently in ships in the port. They are also stated to have been found in one or two warehouses in the Trafford Park District of Stretford.

DAMAGE DONE BY RATS.

No attempt has been made to estimate the amount of damage done by rats in the city, but it must be very great. In addition to the food consumed, the amount which is destroyed is considerable, especially in premises where grain, meat, sugar, etc., is stored in sacks. Recently a large part of a consignment of fresh tomatoes which was stored in the basement of an old building, was destroyed during one

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